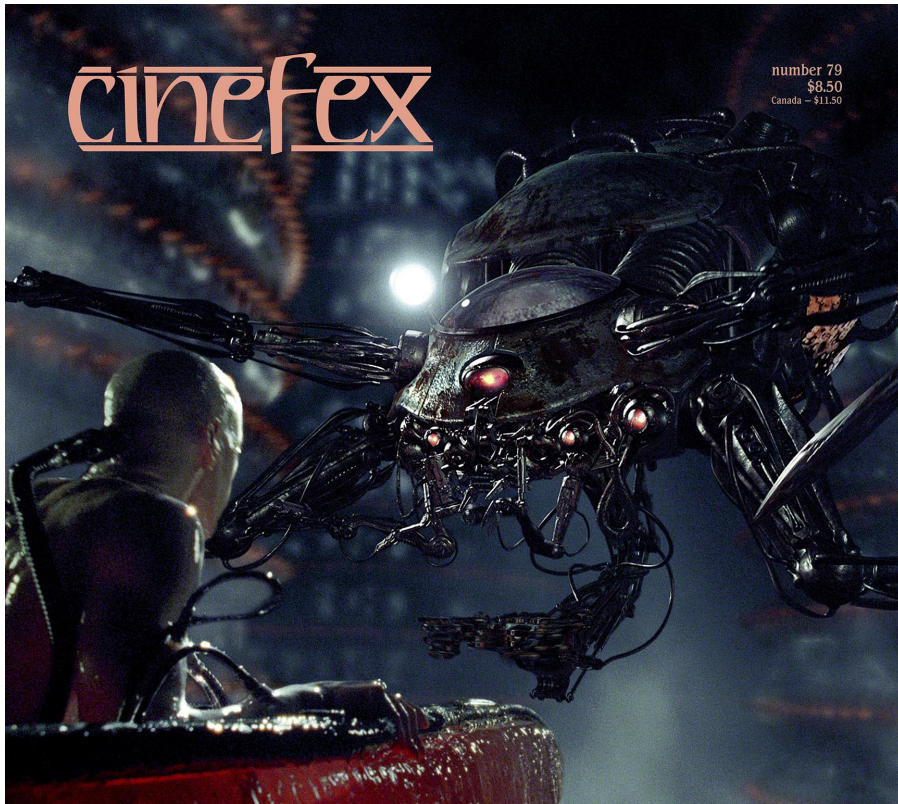


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 associate editor
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 staff writer
 Kevin H. Martin
 senior contributor
 Mark Cotta Vaz
 advertising director
 Bill Lindsay
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 circulation associate
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A Walk on the Wild Side 15

With source material plumbed from the popular sixties television series,
 director Barry Sonnenfeld's *Wild Wild West* offered up a comic saga of
 Old West derring-do pitted against outrageous villainy and bizarre gad-
 getry. Makeup effects by Rick Baker, physical gags by Michael Lanteri
 and digital creations by Industrial Light & Magic and Cinesite enlivened
 the proceedings. *Article by Kevin H. Martin.*

The House That Roared 45

In *The Haunting*, based on the novel by Shirley Jackson, the malevolent
 spirit of a killer manifests itself in a gothic mansion, turning imagined
 threats into nightmarish reality for the unwitting subjects of a psycho-
 logical study. Director Jan De Bont sought the talents of effects maestro
 Phil Tippett and production designer Eugenio Zanetti, among others, to
 inject new life into the eerie tale. *Article by Christine Sandoval.*

Jacking Into the Matrix 66

Offering up a mix of stylish martial arts and cerebral science fiction, *The
 Matrix* – the brainchild of writer-directors Larry and Andy Wachowski –
 offered a singular vision of a world where reality is nothing more than an
 elaborate computer construct. Visual effects were achieved principally
 by Manex Visual Effects and Dfilm Services, with assists from other firms
 in both the United States and Australia. *Article by Kevin H. Martin.*

Devils in the Deep Blue Sea 94

Mako sharks, armed with enhanced intellects and super-predatory in-
 stincts – the result of genetic experimentation on board an aquatic re-
 search station – turn on their captors in the Renny Harlin thriller, *Deep
 Blue Sea*. Animatronics innovator Walt Conti teamed with visual effects
 supervisor Jeffrey A. Okun and a host of digital effects facilities to com-
 plete the project. *Article by Estelle Shay.*

COVER – Apparent reality is revealed as a virtual construct in *The Matrix*.

A WALK ON The Wild SIDE

ARTICLE BY Kevin H. Martin



Airing on the CBS network from 1965 to 1969, *The Wild, Wild West* television series depicted an American West retrofitted with Jules Vernesque trappings such as labyrinthine subterranean lairs and submarines masquerading as sea monsters. Two United States Secret Service agents, the intrepid James T. West (Robert Conrad) and master-of-disguise Artemus Gordon (Ross Martin), would counter threats to the realm that ranged from the mundane-baddies recycled from countless westerns past to the ridiculous kind of übervillain dominating movie screens in the then-yearly James Bond films.

While several early black-and-white episodes told tales of political intrigue in which the agents were called upon to thwart assaults on the presidency of Ulysses S. Grant, that rookie season also introduced the first in a seemingly endless line of mad scientists. Among the most memorable was Dr. Miguelito Loveless (Michael Dunn), a brilliant dwarf with a diabolic bent. The diminutive super villain surrounded himself with beautiful women – most of whom would eventually fall prey to Jim West’s charms – and became a Moriarty-like foil for the agents, turning up regularly throughout the series’ run.

Loveless’ plots grew increasingly outrageous once the show switched over to color. In one episode, he trapped the heroes in an alternate universe of his own creation—one existing within the two-dimensional vistas depicted in his paintings. As with many television programs of the period, such as *The Man From U.N.C.L.E.* and *Voyage to the Bottom of the Sea*, this element of the fantastic eventually overpowered *The Wild, Wild West*, straining audience credulity to the breaking point with episodes involving time travel, miniaturization of human beings and even UFOs.

Jim West’s brow had always remained studiously fixed, no matter how ridiculous the situation in which he found himself. But when the inevitable TV-movie followup was filmed a decade later, this play-it-straight approach changed. Michael Dunn had died, and so Paul Williams took on the slightly less diminutive mantle of Loveless’ offspring. The high-camp result – *The Wild, Wild West Revisited*—threw the series’ tenuous balance between humor and adventure considerably out of whack, as did its followup, *More Wild, Wild West*.

After Ross Martin also died, no further attempts at revival were mounted until 1992, when Warner Brothers announced plans for a feature film derived from the series. Intended as a Mel Gibson vehicle, it was to reteam the actor with writer Shane Black and director Richard Donner from *Lethal Weapon*. But Gibson – who had also been linked to a big-screen version of *The Avengers* – instead wound up working with Donner on another TV-show-to-feature, *Maverick*. Later, a screenplay written by brothers Jim and John Thomas stirred interest in the project anew. S. S. Wilson and Brent Maddock created an alternate script – reportedly featuring authors H.G. Wells, Jules Verne and Mark Twain at work for the U.S. government, dreaming up the sorts of gadgetry that appeared in their later prose works as fiction—which crystallized the studio’s intent to proceed. After director Barry Sonnenfeld signed on, Will Smith and George Clooney were enlisted to play West and Gordon; so another draft, by Peter S. Seaman and Jeffrey Price, was tailored to their specific tastes and talents. Clooney soon departed the project, however, and Kevin Kline stepped into the role of Gordon.

Ultimately, the picture—its title compressed to *Wild Wild West*—altered histories and heritage for both *West* and *Loveless* (Kenneth Branagh), in a prequel story explaining how the Secret Service was formed and recounting the initial teaming of West and Gordon. Now working as an army officer who had escaped slavery as a youth, West would nonetheless retain his dandy, trademark bolero jacket, and Gordon would still use his mastery of disguises as a primary investigative tool. But the villain – though still possessing that devious predilection for criminal mayhem—would change from a half-pint half-Hispanic to a rich southerner whose service in the Civil War has left him crippled and legless. *Loveless*’ never-healed rage over his injury, coupled with feelings of injustice regarding the victory of North over South, leads him to plot with representatives of various European powers to conquer the United States and divvy it up amongst themselves. Captain West and U.S. Marshal Gordon team up to stop the mad doctor, who kidnaps the country’s leading scientists and, eventually, President Grant (also played by Kline), making off in his Tarantula, an eighty-foot-tall, multilegged, fireball-spewing mechanical transport. While attempting to rescue the president, the agents wind up inventing the world’s first powered aircraft, which they subsequently take into battle against the doctor’s walking war machine.

To realize much of the film’s spectacle, Sonnenfeld turned to Industrial Light & Magic, which had provided visual effects for his previous picture with Will Smith, the phenomenally successful *Men in Black*. Other *Men in Black* returnees included makeup effects maestro Rick Baker, whose Cinovation Studios created all manner of prosthetic disguises for the agents, and production designer Bo Welch, responsible for conceptualizing *Loveless*’ array of steam-powered nightmares. Special physical effects – running the gamut from large-scale pyrotechnics to Rube Goldberg-style articulated contraptions—would be overseen by Michael Lantieri, while additional 2D visual effects were provided by Cinesite.

ILM producer Jacqui Lopez and visual effects supervisor Eric Brevig had both worked with Sonnenfeld on *Men in Black*. “That first time out provided Barry with an education in visual effects,” said Lopez. “On this show, we were working with a director who knew what to expect from us, which made a huge difference. He had effects sequences storyboarded early on, which gave R&D and our other departments more time to prepare for the project’s challenges.”

While the lion's share of the animation effort revolved around the evil doctor's eighty-foot-tall armored mechanical transport, other CG animation elements included Loveless' mechanical legs and a rocket-powered, flying bicycle piloted by Gordon and West. Tasked with the animation chores was a crew of just seven animators, overseen by animation supervisor Dan Taylor. "The department was originally slated for fourteen people," said Taylor, "but I said that by picking the right animators - ones I had worked with previously and knew could deliver - we could get by with less." Fortunately, Taylor's magnificent seven were all available when the show crewed up, and the work proceeded as scheduled, with a clearly established hierarchy in place to review the animation. "In addition to regular suggestions from Eric Brevig, we had Barry Sonnenfeld reviewing our stuff every week. Barry provided solid feedback; and because he was not involved in the animation on a day to day basis, he could view it with a fresh perspective, which was extremely useful."

During preproduction, which spanned four months, the director involved ILM with principal art direction issues. This meant heavy interaction with Bo Welch and art director Tom Duffield, who were conceptualizing and constructing Loveless' self-described 'Mechinology' - a design style well ahead of its time. "I took the job because of that aspect," Welch stated. "It was high-tech, but in a heavy-tech way. Loveless is from New Orleans and a futurist, so I decided he would be interested in cast iron and glass architecture. While these stylings had emerged in Europe - the Eiffel Tower is a good example - they hadn't yet reached the U.S. It made for a lovely look - heavy metal combined with destructive function, incorporating a decorative overlay that reflected remarkable craftsmanship." The other design influences were the mad doctor's personal obsessions. "Everything around Loveless is leg- or phallus-oriented, since, being chopped off at the waist, he has neither."



In Wild Wild West, James West (Will Smith) and Artemus Gordon (Kevin Kline) use a bizarre projection technique to view the final retinal image of a murdered scientist. Rick Baker, makeup effects creator for the film, produced the decapitated head.

Like the old TV series, the movie begins with a pre-credits 'teaser' scene – though instead of involving West immediately, as the series was wont to do, this nighttime segment revealed a deadly edge to Loveless' gadgetry. Professor Morton (Michael Sims), a panicked figure with a large metal collar affixed to his neck, attempts unsuccessfully to flee from an airborne, razor-sharp disc. The disc, drawn to the professor by magnets imbedded within the collar, decapitates The Man on contact.

Except for a single shot at the end of the sequence, the disc was handled entirely as a digital effect by ILM. But instead of using the company's traditional, established CG pipeline, the work was accomplished in Sabre – ILM's near-real-time compositing system. "The teaser sequence was added late in the schedule, at a point when time was no longer a commodity," said associate visual effects supervisor Pablo Helman. "So we brought the disc geometry into Sabre. Using camera data generated in the match-move department, we proceeded to light and render the disc." Bringing match-move data and animation into Sabre had rarely been undertaken in the past, but with the great number of cuts featuring the disc—both here and in a later cornfield sequence—the use of Sabre eliminated a possible bottleneck. "We could turn a shot around in four hours instead of the usual take-per-day from the regular pipeline. The results turned out very true-to-life in terms of rendering. During the plate shoot we'd captured reference of a practical disc, which let us know exactly how our CG disc should look in that environment." Dean Yurke handled the disc animation.



Director Barry Sonnenfeld on set.



Visual effects supervisor Eric Brevig and visual effects producer Jacqui Lopez examine production art at Industrial Light & Magic.

We are introduced to West and Gordon after both men, operating independently and without knowledge of the other, arrive at a brothel where they have tracked the most-wanted General 'Blood bath' McGrath (Ted Levine). West believes McGrath to be responsible for a Civil War massacre that left his parents dead, though it is later revealed that this was the work of Dr. Loveless. Cinovation developed the general's battle-scarred visage. "McGrath's face was all scarred up on one side," stated Baker, "so we went with straightforward foam appliances there. What was really weird about the character was his hearing aid - this Gramophone-looking thing attached to his ear that had to look as though it had been sewn to his skin." When a more elaborate, fluted design for the earpiece was nixed as appearing too flower-like, a worn brass version was created and applied by Ed Henriquez.



Bluescreen photography of Will Smith on a horse was composited by Jeff Doran with matte-painted imagery of the White House for an establishing scene set in period Washington D.C.

At a crucial moment in the brothel confrontation, the two agents clash with one another, allowing the general to escape. During this encounter, Gordon is dressed as a hooker - the first of several disguise makeups employed by the character, all handled by Cinovation. "I told everyone right off that with a big man like Kevin Kline, we could only expect limited success in transforming him into a woman," noted Baker. "I didn't know if we could make him a credible female, let alone an attractive one. My feeling was always that no matter what we did, when the camera got up close, he was going to look like a guy in drag."

Lifts were applied to the actor's face, pulling his skin tighter, while gelatin appliances covered his brow, lips and nose. A standard beauty makeup that featured a heavy use of color-contouring followed, with large silicone breasts completing the illusion. "How realistic we were going to make the breasts was a confusing issue," Baker admitted. "In the script, West told Gordon that he knew Artemus was a man because his breasts didn't move at all. In spite of this reference, Barry wanted them to jiggle, so we went with silicone gel."

As was his usual procedure, Baker developed a look for each of Gordon's disguises, then applied the initial makeups. Once a successful proof-of-concept was achieved, he would then relinquish makeup application duties to Lance Anderson. "On the day I made Kevin up as this woman," recalled Baker, "there was a large call to handle all the other hooker makeups, so numerous other artists were also there. I got a lot of surprised praise for my application of beauty makeup from some of them. 'I thought you just did monsters,' was something I heard several times that day."

With a bickering relationship between the pair now established, West and Gordon next meet up at the White House. Means for establishing the locale and the period—through an exterior of the nation's capital—remained undetermined for a time. “The White House was a good example of how some sequences evolved as a result of early location scouting,” Eric Brevig related. “Production determined that traveling to a location that resembled period Washington D.C. would be a lot more expensive than utilizing a visual effects solution. For Pennsylvania Avenue and the White House, we dressed a park in Van Nuys—in what was probably the most economical use of a non-location ever – setting up a large bluescreen in the middle of some grass.” Digital matte paintings by Mark Sullivan were used to show the White House, along with wider views of the city that featured a ship in harbor and the still-under-construction Capitol dome.

West's meeting with President Grant is preceded by one with Gordon masquerading as the president. But his impersonation only succeeds in provoking West's gun hand, at which point the real president enters, chastising both agents. The concepts for depicting real Grant and fake Grant – both of whom would appear in several scenes later in the movie – underwent radical evolution during preproduction. “I had first intended to do two very different kinds of makeups,” Rick Baker stated. “The real Grant was to have been a much more elaborate application, with a fairly strong resemblance to the actual historical figure. Since it's always difficult to make one actor look like another, I suggested that Kevin Kline play both parts. This approach carried with it the possibility that Gordon's masquerade might be good enough to actually fool people, and Barry went for it.”

Then Baker learned that both halves of the split-screen shots featuring Grant and Gordon-as-Grant would be shot on the same day. “Real Grant was going to be a three-and-a-half-hour makeup and would take another hour to remove,” remarked Baker, “so putting the fake Grant makeup on Kevin after that would have eaten up the whole day. To simplify the process and speed production along, we decided to use pretty much the same makeup for both fake Grant and real Grant – wig, beard, mustache and gelatin nose—with only minor alterations.” Baker's other disguise makeup for Gordon – posing as an old trapper – featured only paint and hair, with no prosthetics required.

When the real chief executive orders West and Gordon to join forces and investigate the puzzling disappearance of the nation's leading scientists, the pair depart Washington aboard the Wanderer, a private train packing numerous gadgets. The train was one of the original show's most memorable icons, and was thus one of Bo Welch's most important design concerns. “Our train wrangler showed me a lot of engines from the late 1800s,” recalled Welch, “and while any of them would have been fine for a traditional western, I wanted a locomotive from an earlier time, which are now very rare. The earlier trains had huge drive wheels that were very expressive, which was important because this train was a character in the film and the audience had to travel along with it. The engine's appearance was an important issue.”

American, a William Mason-class locomotive and long out-of-service museum piece, underwent a painstaking overhaul before it could go before the cameras as the agents' home away from home. The lovingly restored steam engine was brought west for scenes shot in New Mexico and

Utah. The other two cars making up the Wanderer – a lab car and the parlor/sleeping car–were specially constructed by Welch’s art department to pull double duty. After being mounted on a gimbal on stage for a number of interiors–with bluescreens set up outside the numerous windows for later in section of moving backgrounds–they were shipped east and fitted out to run on the rails as functional train cars towed by American.

As they head out on the Wanderer, the agents’ only lead is the decapitated head of Professor Morton. Gordon mounts it on the ‘skull master’ – a gruesomely whimsical gadget capable of projecting the final image captured on a dead person’s retinas. This scene – shot long before Morton’s decapitation had been conceived – featured a head cast of Cinovation’s Mitch DeVane. “At one point Barry wanted to put my head on the skull master,” Rick Baker commented, “while later he considered using his own. Since we wanted someone with features suggestive of the period, I suggested Mitch, whose appearance made me think of Civil War photo graphs.” After DeVane’s lifecast was taken, a silicone head was produced, with hair punched in and translucent acrylic eyes inserted. “They needed to project light through his eyes, so we installed a fiber optic system inside that would backlight his pupils while adding a lantern-like flicker.”

The agents next pay a visit to Loveless’ New Orleans mansion, where the mad scientist makes a first, spectacular appearance. A float, featuring the oversized head of Abraham Lincoln, explodes, with the doctor rising into view from within. With Kenneth Branagh installed beneath the head, inside the float, Michael Lantieri used only minimal pyro on the sculpted visage of Lincoln, blowing most of the head away with air. The doctor is revealed to be merely a head-and-torso with arms, set into a steam-powered wheelchair. Bo Welch explored various methods for hiding Kenneth Branagh’s legs within the wheelchair. “We considered doing it with mirrors,” stated Welch, “but that approach would have meant setting up for a fixed camera angle – and Loveless needed to move around a lot. So this meant visual effects were going to be needed to effect lower-body removals.”

ILM had done groundbreaking work in digital leg removals for actor Gary Sinise in *Forrest Gump*, but this project was even more extensive. “We put Kenneth Branagh in blue tights so his legs could be split out,” said Eric Brevig. “Still his legs blocked the camera’s view of parts of the wheelchair, so we not only had to rotoscope out his legs, but animate a CG model of the missing pieces of the wheelchair, then composite them into the shots. Later, for the scenes in which he stands up on metal, spider-like legs, Kenneth also had to wear a box around his midsection to conceal his trunk. Our camera was below floor-level to get extreme up-angles, which meant building one-by-six planks for Kenneth to walk on while he straddled the opening containing the camera. It



A tank– the brainchild of megalomaniac Arliss Loveless– takes to the rails via a transformative effect involving a full-size prop vehicle built by special effects supervisor Michael Lantieri and its animated digital counterpart created by ILM.

was a precarious business, because with that box on his hips, Kenneth couldn't even see his own feet. The whole thing must have been an affront to his dignity—a 'how far can I push this guy?' situation. Barry, being a ribald guy, said to me afterward, 'The only thing I didn't ask Kenneth to do was drop his drawers and wear a witness mark on his privates.'"

West, distracted by one of Loveless' bevy of deadly beauties, nearly falls prey to gunmen who step right out of some paintings on the walls of the doctor's home. Rather than turning to digital sleight-of-hand for the emergence effect, Bo Welch elected to try an on-stage solution. "We hired Glen Eytchison," explained Welch, "who used to do the Laguna Beach Pageant of the Masters—a sort of live-action recreation of classic art. Acting as a design consultant, he set live actors up inside picture frames, attaching them to armatures hidden inside the paintings, then painted and lit the performers to appear two-dimensional to the audience, so they blended right into the artwork surrounding them." Eytchison's illusion – similar to what he had engineered for films twice previously, in *Ghostbusters 2* and *The Devil's Advocate* – allowed Sonnenfeld to capture the entire effect in-camera.



Visual effects art director Alex Jaeger at work on animatics for the tank's descent onto the rails.

Loveless is next seen aboard his paddle-wheel steamboat, hosting a clandestine meeting attended by General McGrath and representatives of several foreign powers. While the live-action deck was shot blue screen on stage, wide views of the vessel in the water used a miniature built by the art department. "We wanted something that looked like a Civil War-era ironclad," commented Welch. "It was built as a twenty-foot-long, quarter-scale miniature that went onto floats so we could shoot it on a lake. At that size, scaling issues with water were not too prevalent. The live-action stage element could then be composited into the location miniature plate after the fact."

Loveless' amphibious tank, *Black Death*, makes its first appearance after the meeting, rising from the water before opening fire with Gatling gun and cannon. Like most of the movie's constructs, this vehicle – from chassis to spiked wheels – was built from cast iron. "To get that period look," Michael Lantieri explained, "the metals all had to be forged, heated and then bent by hand, which meant it took three times as long to make the tank. The finishes had to look crude but functional. Even the way our steel was treated differed greatly from the norm, since we couldn't use modern tools to make square-edged cuts." To expedite matters in some cases, Lantieri's crew built devices conventionally, then rounded off edges and created a patina finish to make each item look as if it was produced in a blacksmith's shop.

As a multi-terrain vehicle, *Black Death* was well ahead of its time, though design influences for the juggernaut were rooted in the period. "It was supposed to be like the first armored car," commented Lantieri, "but patterned after a period stagecoach. We built on a Bobcat frame—utilizing the existing drive train so it could be piloted across land—then assembled this Victorian-era attack wagon around it. Thanks to the efforts of Corey Fushei and Tom Pahk, it could run on

land or, with a cable assist, roll on rails and move through water.” To make the vehicle function on train tracks, the rig would clam shell around a locomotive engine while deploying a separate set of wheels as it settled onto the rails. Lantieri’s team was already well-acquainted with the challenge of putting unusual objects on train tracks, having tackled a similar challenge with the DeLorean auto in *Back to the Future III*.

In a display of the machine’s firepower and of Loveless’ philosophy – that Mechinology outstrips the capabilities of mere men—General McGrath’s troops are mowed down mercilessly by the doctor’s armored vehicle, with the general falling prey to Loveless himself. When West and Gordon arrive on the scene, they learn that Loveless intends to disrupt a ceremony—presided over by President Grant—commemorating the historic joining of two rail way lines at Promontory Point, Utah. Discerning that Grant is the obvious target, the agents set off in *Wanderer* after the doctor’s tank, which has enfolded a train engine and headed west.

Wanderer gives chase, pursuing *Black Death* into a tunnel, but when West’s train emerges from the other end, the tank train has vanished. After recording *Wanderer*’s passage out of the tunnel, the camera holds on four filigreed structural elements outside the exit, which telescope inward, collapsing down in segments and revealing themselves to be articulated legs that have lifted the tank train up off the ground. The tank train settles back onto the tracks and sets off after West’s train – turning the pursuer into the pursued—while its legs are still retracting back inside the body.

Together with associate effects producer Vicki Engel, Pablo Helman traveled to Idaho for the plate shoot. “We only had one day to shoot everything,” said Helman. “We spent the first six hours inside the tunnel, surrounded by bats and rats, watching it rain. With our team, plus everyone else needed to move the tank train, there were about a hundred people in there. The sun was out for just twenty-five minutes, but we managed to shoot all the necessary plates in that time.” *Black Death* was positioned on the tracks and photographed at the exact point where its digital counterpart would descend into frame for the settling-down shot. The tank was then joined to a practical engine and towed out of frame for the followup showing the tank train beginning its pursuit of *Wanderer*.

Black Death’s segmented, articulated legs were entirely digital. While at first it was thought that shaders could provide the desired rivet-covered look and texture, that simple approach did not ultimately suffice. “We needed more detail,” Helman said, “and that meant using Viewpaint. The leg detail wound up consisting almost entirely of painted textures.” When the legs collapse downward, each contraction produces a shudder—an action that not only suggested the weight of the train but also took the curse off too-perfect CG animation. “Barry didn’t want the elevator effect on these legs to look too sophisticated, so John Zdankiewicz’s animation took gravity into account, as well as the limits of period workmanship. That gave it a lot of credibility with respect to the train’s mass, because this thing was supposed to weigh four hundred tons. Hilmar Koch did a great job as TD for this shot.”

To depict *Black Death* descending into view and settling onto the tracks, a combination of live-action and digital imagery was required. “We took a frame of the real train sitting on the tracks,” said Helman, “then used *Make Sticky* to map that image onto Simon Cheung’s 3D

geometry—essentially projecting the practical train onto a digital model. This meant the lighting couldn't be changed, but since there wasn't a great change in perspective—the train was just descending while the camera remained static—we could get away with it.” The following shot of the practical train moving off was enhanced by the digital addition of hinges and a storage area near the back of the vehicle on either side. “That gave us a new section on the train, into which the legs could retract. Articulated covers fold shut over them as the train passes camera.”

Loveless targets the Wanderer, requiring fast response from the beleaguered agents. West uses a built-in revolving pool table to deposit him beneath the train car, then mounts the Egressor, a Gordon-designed rig that should permit him to slide back on the tracks to the pursuing tank train. While a few of these shots were achieved via bluescreen, the majority featured Will Smith on a Michael Lantieri rig that ran on the actual train tracks. Over twenty shots in the sequence required either wire or rig removals, accomplished at Cinesite. “A number of these shots were extremely close views of West looking down the tracks with the wires a few inches off the railroad ties,” explained Cinesite digital effects supervisor Thomas J. Smith. “West’s line breaks and he has to lasso the underside of the other train with Gordon’s special rubber rope, which snaps him back and forth like a rubber band beneath the train. For those wire removals looking down the tracks, we solved perspective issues by using Elastic Reality.”

West succeeds in crippling Black Death, leaving it dead on the tracks as he pulls himself back aboard Wanderer. Loveless retaliates by launching a huge harpoon-like arrow—trailing a heavy metal chain—that rips through the Wanderer’s sleeping car before anchoring itself, stopping the train cold. “We had an all-practical shot from outside the train looking in through the windows,” related Lantieri. “It followed the twenty-foot arrow as it flew through the car. We attached it to a cable and then pulled it ahead winch-style. For the trailing chain, we used a plastic with wire inside and a bungee attached to maintain tautness.”

To augment the real arrow and chain, Simon Cheung built CG versions and brought them into Sabre. “That system was very good at dealing with the animation of solid objects,” commented Pablo Helman, “and also let us paint interactive light to sell the arrow’s passage through the train car.” The work was complicated by the lack of background plates, which were required for views looking out the car’s back door and windows. “The plates were supposed to be done when we were in New Mexico, but this part of the picture hadn’t been boarded by that point. As a result, we didn’t get any backwards-facing views from the train car— which would have featured Loveless’ train

attached to the far end of our long CG chain.” Lacking plates for three shots, Helman began assembling the needed backgrounds in Woodland Hills, where stills of the practical tank train on rails were taken from an appropriate angle. These were combined with photos of the New Mexico cornfields. The completed backgrounds were then composited with the live-action train



West and Gordon watch in awe as the Tarantula— a mechanical juggernaut and Loveless’ crowning achievement— climbs into view.

interior by 2D compositing supervisor Jeff Doran. The digital arrow and chain were added by Sabre artist Grady Cofer.

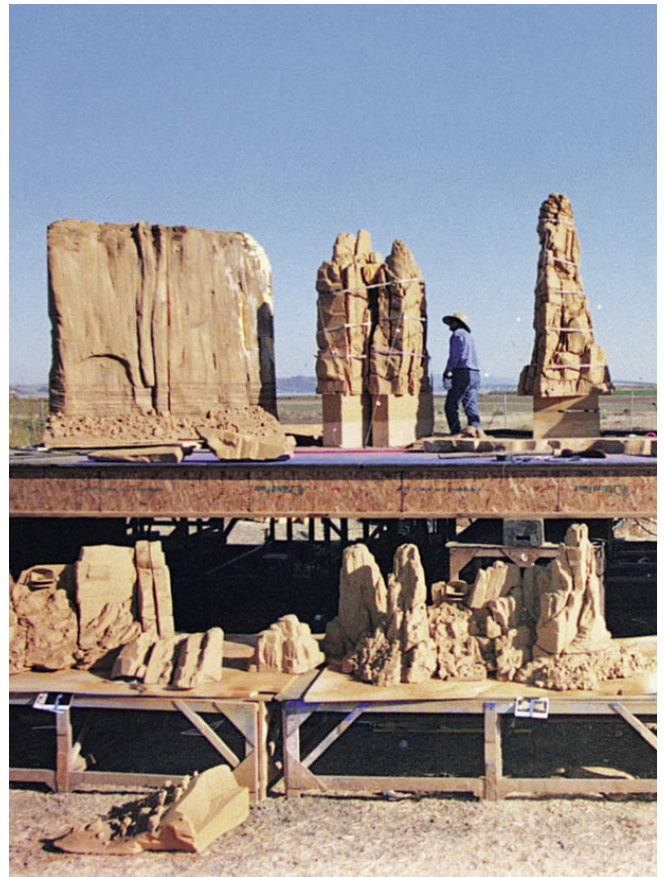
West and Gordon are captured by Loveless and soon find their necks in the proverbial wringer as the doctor attaches to each of them the same kind of metallic collar that proved to be Professor Morton's undoing. The device that fires the razor-sharp pursuit discs was fabricated by Lantieri's crew, and featured a mechanism that started the discs spinning before propelling them away at speed.

The agents attempt to outrun the deadly discs that have targeted them, ducking and crisscrossing through a cornfield. Eric Brevig photographed both background plates and coverage of stunt doubles to augment the main-unit work with the two stars. "There were a few views of the real disc spinning, with its saw-toothed blade, but that thing was too dangerous to use in proximity to our stunt people and camera crew," related Brevig. "So we decided to put a static disc in front of the camera to create real interaction as it passed through the cornfield, knowing that we could comp a spinning, seriously-sharp-edged CG disc over it later." To move the disc ahead of the camera, grips pushed a rig holding the prop. Pablo Helman oversaw animation for the sequence, which was augmented with particle work that created much of the interaction between disc and cornstalks, including the resulting debris.

A God's-eye view of the agents being pursued by the discs was filmed with the camera mounted atop a locked-off crane. To create the physical interaction necessary to suggest the passage of discs from this angle, two passes were required. After the West and Gordon stand-ins sprinted through a specific arc of action in the field, disc 'hats' were fitted to the heads of two other performers, who were instructed to move along the path of the pursuing discs, creating physical displacement. As was the case with the disc rig, CG discs were composited over the disc hats.



For a scene in which the Tarantula pulverizes three towering rock formations that block its way, model supervisor Lorne Peterson and crew built a miniature set patterned after Monument Valley. Pyrotechnics and ram-actuated elevators inside the formations caused them to collapse on cue.



For a scene in which the Tarantula pulverizes three towering rock formations that block its way, model supervisor Lorne Peterson and crew built a miniature set patterned after Monument Valley.

Pyrotechnics and ram-actuated elevators inside the formations caused them to collapse on cue.

West and Gordon leap off a cliff to avoid being decapitated by the discs, which collide and explode. The agents splash down safely in a mud

bank, then set off on foot in search of their train, which has been stolen by Loveless. Eventually Gordon finds himself being pulled across the desert by magnetic attraction, his metal collar dragging him to the sought-after railroad tracks while West watches with amusement. These cuts required wire removal and compositing at Cinesite. "The opening shot in the sequence was the toughest," Thomas J. Smith related. "It was a twenty-four-second bluescreen shot where we had to completely rebuild the back ground, taking out tracking markers, clouds and a road that appeared between them—all on a moving plate." Doug Tubach composited the shot, adding some camera movement to the scene. Reaction shots of West watching his partner being dragged combined bluescreen footage of Will Smith with Monument Valley background plates.

Eventually, West and Gordon find their train, abandoned near the rim of a canyon within Spider Valley – Loveless territory. Then they proceed to the edge of a cliff, at which point shooting switched from location filming in Sante Fe to a bluescreen studio setup. "I wanted to shoot the whole sequence outdoors," Eric Brevig stated, "but we just couldn't find a location. There were a lot of color-correction issues with this approach, plus it meant creating the back half of the scene from whole cloth, which is a method I avoid when possible." A partial stage set created terrain for the actors to walk upon, with backgrounds assembled from still plates that were tiled together.

Venturing to the lip of the precipice, the agents are agape at the sight of a vast glass-and-metal industrial complex that spans the base of the chasm before them. "Loveless' lair was mostly Mark Sulli van's digital matte painting," observed sequence supervisor Hayden Landis. "There were also moving elevator cars, plus some fire elements, along with particle smoke emitted from the facility's smoke stacks – enhancements animated, for the most part, by Lindy Wilson."

As the agents strive to absorb what lies before them, Loveless' giant Tarantula – a multi-legged construct capable of independent motion and considerable firepower – climbs into view. Visualizing the transport was the first project Bo Welch had embarked upon for the movie. "The Tarantula embodied all of Loveless' anger, so it was a very important prop," explained Welch. "It took me a long while to work out the design. I figured Loveless had developed this machine over a period of time, and since it was made from raw cast iron—unprotected metal that's been exposed to the elements—there would be some corrosion. We built a partly-detailed maquette so Barry could see the kinds of camera angles that would be possible, and that went up to ILM so they could get started on the CG aspect and perform motion studies."

Though full views would require a digital model, a portion of the transport's head was built full-size. "The goal is always to build as much as possible," remarked Welch, "just to be able to get something on camera. With that in hand, it is easier to set the tone for CG work." The Tarantula's open bridge, located at the front of the head, would carry many of the principal players and be the focus of considerable activity. To accommodate various cinematic demands, two separate bridge sets were built full-size by the art department. "We had one lightweight bridge set that was mounted on a motion base and could be tilted at extreme angles to suggest

the transport's walk cycle. That was used in wide views that required the set to be composited into ILM's fully-CG Tarantula, and usually we just put stunt personnel aboard due to its extreme actions as it rocked back and forth. Then there was a more heavily constructed bridge used for closer shots featuring the real actors." Pieces of that bridge set could also be taken on location and mounted on a crane or lift, allowing for in-camera views from the bridge as it overlooked natural surroundings, thus eliminating the need for composite work.

From an effects standpoint, the armored transport was a Victorian-era, steam-powered answer to ILM's own previous work on the Imperial Walkers seen in *The Empire Strikes Back* and *Return of the Jedi*, which had been realized through stop-motion animation. The computer generated Tarantula, however, festooned with cables and tubing, required far more detailing. ILM art director Alex Jaeger drew a number of close views before the modeling department began digital construction. "One contribution I was able to make involved the Tarantula's feet," commented Jaeger. "Originally they were just solid pieces; but I added wheels that suggested springs and counterweights in action to create compression during the transport's footfall, so the heavy impact would be absorbed."

Though the transport featured bilateral symmetry, allowing opposing legs to be simple mirror images, the four legs on each side were unique, with the forward and rear legs longest to pull and push it along. This meant that four separate pairs of leg had to be designed instead of a single appendage that could be replicated seven times, increasing the CG modeling and rendering difficulties. Other design refinements wound up being either driven or affected by CG rendering dictates. "There was a latticework on the sides of the Tarantula head that let light filter into the lower level," added Jaeger. "Originally, it was going to be much more open in this area, so the people inside would be visible in all the shots. But once we realized how huge this polygonal model was going to be, the notion of adding moving figures inside it made the render times prohibitive."



Eric Brevig and animation supervisor Dan Taylor study a shot of the computer generated Tarantula.

Once the transport design was approved, ILM's modeling department began its work in earnest. "The model was at least as complicated as Draco in *Dragonheart*," Simon Cheung noted. "By counting the number of control vertices, the Tarantula was six times more complex than the T-rex in *Jurassic Park*. I started by modeling the legs, creating a separate scene file for each. The body and head were also separate scene files, to which the leg geometries would be parented."

As Cheung completed each scene file for the model, it was passed to the viewport department for image texturing. Viewport had undergone a much-needed upgrade during production of *The Phantom Menace*, with its newest incarnation able to cope with multiple mapping issues simultaneously. Rather than having to reassign textures to each surface piece, all texture and surface-effect designations could be dealt with at once within the node-copying function of the revamped software. These improvements to Viewport continued during *Wild Wild West*. "It

took us a good month-and-a-half to work out all the various issues associated with this huge, predominantly polygonal model,” viewpainter Bridget Goodman commented. “I could only get true feedback during dailies, when I saw how the desert lighting mixed with the paint. It was like viewing a digital wedge-test. If an area became washed out, I knew to beef things up by increasing detail and contrast in those areas on a shot-by-shot basis. It was a painterly approach to a photo graphic process.”

The first portion of the Tarantula received by Goodman was the body. Minimizing the model’s density to streamline rendering was a big part of the challenge, and viewpaint aided in this through painted bump and displacement maps to create surface details that would otherwise have had to be modeled. “All of the beams and panels on the body model featured areas where rivets needed to be,” said Goodman. “So we hand-painted all the rivets, as well as the suggestion of raised edging on the flat patches of geometry.” The numerous layers of viewpaint utilized on the Tarantula body included several transparency maps, which were employed to create Victorian deck railings and latticework, details that turned up on the sides of the head, as well. For sunlit highlights on the metal, Goodman used scratch maps and specular maps to bring out the desired hot-spot quality, while rust maps voided any specular in the rusted areas.

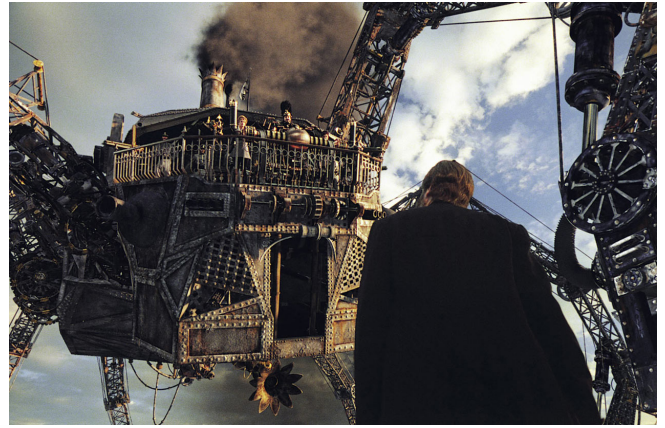
Next up for the viewpainter was the Tarantula’s head, on which Eric Brevig-pleased with the look Goodman had achieved on the transport’s body-wanted more detailing. “I got some photo reference of the full-size head from production,” remarked Goodman, “but it looked different from what I was doing – they didn’t have as much detail on theirs. I didn’t want there to be a problem with inter cutting, so I lightly detailed the top of our CG head in order to match.”

Later, Goodman was able to apply considerably more detail to the belly and other areas not being constructed full-size by the art department. She soon realized that a straightforward and uniform approach to painting the Tarantula might prove less than inspired, and came to a conclusion about the transport’s texturing that mirrored Bo Welch’s own earlier deductions. “I drive on three bridges every day,” Goodman explained, “and while on the road, I realized that if this thing were a clean metal with rivets – like the San Francisco Bay Bridge– it would look boring. Out in the desert, raw steel quickly rusts as the metal oxidizes. Applying that fact to the Tarantula increased the level of visual interest. So I began to study passing trucks during my daily drive, seizing on the visually interesting aspects of their decay and incorporating that. Even though it seemed to me that I was pushing it a bit far, everyone liked the heavily detailed belly renders.” Goodman reworked the main body to reflect the belly textures; and Tony Sommers tackled the master leg, completing the viewpaint process.

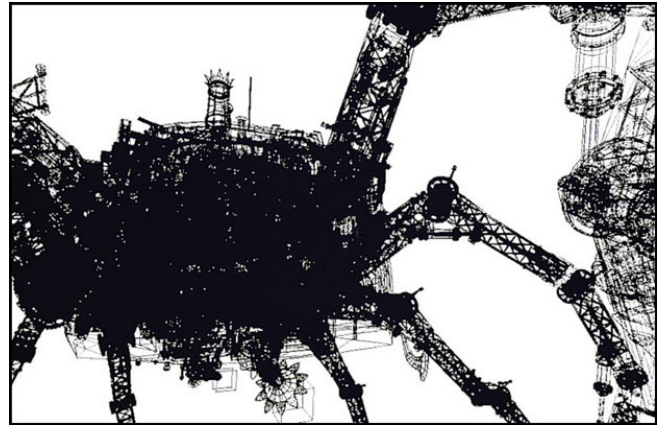
All of the scenes featuring the Tarantula were first visualized in animatics that used a much simplified version of the digital model. “By omitting all the cables, and making the legs out of simple cube forms, the renders went very quickly,” recalled CG supervisor Steve Braggs, who was responsible for all the setup, lighting and rendering of the shots. “Enough of the transport was there that Barry and Eric could choose lenses and camera setups they wanted, preview rough animation, and see how various cuts played together before shooting the plates on location.”

ILM was also able to utilize the camera move and motion data from the animatics to drive production’s motion base bridge set. “The animators figured out what the walk cycle would be during the animatic phase,” noted Brevig. “Then we could take that animation move file and apply the data to the gimbal action of the motion base. That way, when I shot the bluescreen figures on the tipping bridge set, the shot would contain the same motion and perspective changes as the animatic. The blue screen bridge element would then fit into the CG Tarantula move, which also worked from the animatic data.”

The approach, while fine in theory, did not fully translate in the execution phase. “The motion base couldn’t duplicate every tiny aspect of the animatic move,” stated Hayden Landis. “Fortunately, a plug-in for our compositing program enabled us to take that almost-right bluescreen element and place it on the digital model, allowing it some freedom from the limits of the original stage move. This required us to divide the bluescreen element up into several different pieces – such as the foreground railing and the roof of the bridge–so they worked with the actual geometry and perspective of our CG Tarantula, each tracking in flawlessly. Also, since the on-set lighting was different from that of the location plates, tons of color-correction tweaks were involved.”



Loveless and his Tarantula disrupt the historic Golden Spike ceremony. Footage of Kevin Kline, playing President Ulysses S. Grant, served as the plate into which the CG Tarantula was composited together with a bluescreen element of Loveless and his cohorts on the transport’s bridge.



Loveless and his Tarantula disrupt the historic Golden Spike ceremony. Footage of Kevin Kline, playing President Ulysses S. Grant, served as the plate into which the CG Tarantula was composited together with a bluescreen element of Loveless and his cohorts on the transport’s bridge.



Though the Tarantula walk cycle had already been worked out in preproduction by Dan Taylor and his crew—in collaboration with Sonnenfeld—the speed of the transport’s movement through frame was a matter of some debate. “Barry wanted it moving slowly to emphasize mass,” said Taylor, “but I

wanted to see just how fast and energetic it could be without losing that sense of great mass. We looked at some tarantula reference, but even big tarantulas look practically weightless. There were no useful weight cues there, because there was no bodyfall. We decided to add some bodyfall and rocking action to increase the mechanical feel, and that got us some of the way on the mass issue. Each time a foot fell, that weight got translated through the body, with the rocking a natural result. We also added a shock-absorber-type bounce at the point where the leg joined the body. Our early tests had bodyfalls and rocks for each of the eight footfalls in a walk cycle; but that many footfalls lost us the sense of mass. Instead, I decided to key off just two legs. If it was coming towards us, we took the footfalls off the front legs; going away, we’d key the back legs; on side angles, whichever leg was prominent in frame as it fell became a key for us, and we’d use that to transfer the weight into the body in a rocking action.”

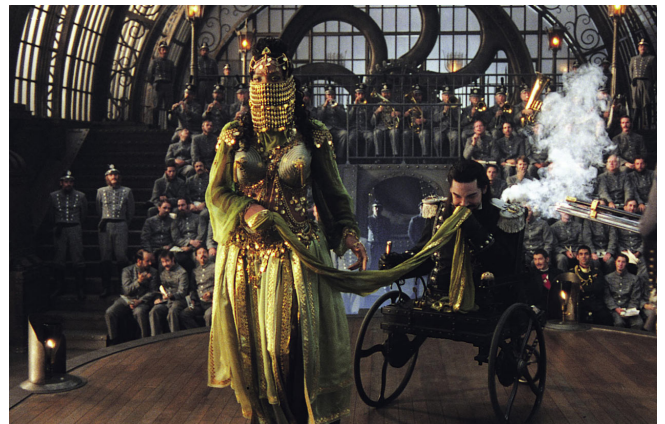
Initially, no one had planned for up-close views of the Tarantula. But once it was evident that the picture would contain scrutinizing camera passes, additional levels of reality were added. “At that point,” said Eric Brevig, “we knew that a sense of real physics was needed to convey the mass of this thing. To get the proper swing and sway to all the myriad cables, I knew we’d need to solve dynamics issues, which became at least as important as the modeling and painting.”

Taylor worked with his co-leads, Scott Benza and John Zdankiewicz, to devise gears that would automatically rotate at specific speeds, working in relation to the movement of the individual legs, with pistons that compressed and decompressed.

“We had overrides on a lot of the procedural aspects for the Tarantula’s motion,” said Taylor. “Some of the aspects were driven by Softimage expressions –gears turned based on the angle of a leg, while pistons worked off particular leg positions. But with every one of those automated actions, there was another level of hierarchy available to us. That let us go in and slow the wheels down or adjust the cables when it suited us.”

The movement of cables was driven in part through controls developed by Zdankiewicz and Benza. “There were two kinds of cables,” remarked Taylor. “The taut suspension cables that extended from towers on each leg was one, which featured hand-animated vibration for the cable whenever a leg planted. Then there were looped cables along the belly, which were

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Disguised as an exotic dancer, West penetrates Loveless’ lair. In depicting Loveless– a Civil War victim– actor Kenneth Branagh wore blue tights so that areas of the film frame obscured by his supposedly amputated legs could be replaced with appropriate background imagery.

supposed to carry hydraulic fluid and the like. We utilized dynamic simulation in Maya to get the swinging action of those cables.” Simon Cheung set up control points for the cables within the model, with Steve Braggs directing these controls in Maya, allowing the cables to swing in a dynamic simulation. In all, there were some 250 dynamic cables set up for each shot.

Another aspect of the transport’s on-screen presence, revealed during its ascent into view, is a dense cloud of black smoke spewing from its exhaust stack. Heading up the smoke, steam and dust effort was CG technical director Craig Hammack. “Originally the smoke had been developed as a background element,” said Hammack, “but Barry decided on a billowy cloud with a great sense of volume, like the black soot filling the air from early locomotives. So Alex Jaeger made up some artwork to represent a three-hundred-foot plume. Once the look was determined, it became a matter of trying to generate particle smoke that wouldn’t bog down these already enormous Tarantula renders. This meant that we couldn’t throw ten million particles at the plume, since complex smoke could double render times. Usually we wound up with fifty to sixty thousand particles. The one exception to that was the first reveal – where we got into five million particle counts–because the smoke is all you see for a few seconds prior to the head coming up into view.” To keep the particle count from climbing, Hammack had to find a way to kill the old particles being emitted from the smoke stack while growing new ones. “I decided to kill particles only after they’d reached the top of the plume–and I would let neighboring particles grow to mask the decaying ones.”

A straight-on view of the Tarantula approaching from a distance and coming right up to the camera presented its own smoke challenge. “We had to take the look of the smoke as seen from a distance,” Hammack said, “and retain that feel while moving into a closer view. We tried beauty-rendering just the three hundred feet of plume; and for the background, we tried a cheat via digital matte painting. Unfortunately, that didn’t hold up in the bright day light conditions.” Ultimately, the rest of the smoke plume was hardware-rendered – an approach that provided no shadowing or lighting, but allowed for enough in the way of animated textures to sell the shot. “We had to do some faking to get the plume to read as though it was stretching all the way to the horizon. Also, the heavy sidelighting partly flattened the smoke in those straight-on shots, so the lighting had to be pulled up to a raking angle to maintain the necessary sense of depth.”

Steam gags were also incorporated into the Tarantula animation. Close shots employed actual steam elements filmed at ILM, while distant views featured CG steam. “There were forty-six separate steam events,” remarked Hammack. “Real steam dissipates very quickly, so making the fadeoffs read credibly was one problem. Another was the lighting–unless the steam was backlit, it looked dead. We had to add a number of lights just to get it to read for some shots.”

The Tarantula steps over West and Gordon and strides purposefully towards a trio of two-hundred-foot-tall rock formations that block its path. The Tarantula removes these obstructions by belching a succession of fireballs that collapse each structure in turn. “There were no computer generated flames used,” said Hayden Landis. “Instead, Tarantula’s fireballs were put together in Sabre by Dean Yurke. After we finished each comp, he would add the weapons-fire by patching the effect together from various real fire elements.”

The rock monuments were products of the ILM model shop. Chief modelmaker for the Monument Valley sequence was Lorne Peterson, who became involved after Jacqui Lopez viewed the rock faces produced for The Phantom Menace's podrace environments. "These monuments were your typical gray-rock structures," recalled Peterson. "We built them as eight-foot-tall miniatures, carved from a very dense urethane foam. The same method was used to create a pair of escarpments placed on either side of frame to fill out the foreground."

The three rocks could not simply fall over, since that would do nothing to clear a path for the giant walking machine to proceed; instead, they needed to collapse straight down. "It was like a building that has been exploded from within at its base," Peterson said. "The object was to avoid producing a pile of debris so big that the Tarantula couldn't step over it, so the pieces had to be heavily fragmented. Since foam has a bounce to it, we needed to counteract that unnatural look for the falling debris. By adding lead beads to each piece, the rock fragments would compact on impact, like a bean bag."

Since the structures would need to be reassembled for multiple takes, a system had to be devised to expedite this process. On Congo, Peterson had experienced a similar situation. "I'd found that by using the same people for construction, maintenance and reassembly, the team could reassemble pieces much faster than you'd think possible," recalled Peterson. "We did the same thing here, but also labeled the backs of the pieces, color-coding the tags to separate the various regions for each structure by height—reds on the bottom, greens above that, then blues."

Triggering the actual destruction—without resorting to an unrealistic level of pyrotechnic force—required a tube to be set inside each rock model before the pieces were set in place. "This formed a shaft down the center," Peterson stated, "and we made a plug that covered the tube and the top of the monument, using ethyfoam—a polyethylene. The plug was just slightly larger around than the tube hole, and connected to a ram at the base of the miniature." When triggered, the ram would drive the plug downward, into the center shaft, causing the surrounding sections of miniature rock to pull apart, starting at the top and proceeding downward. "Everything in this giant jigsaw puzzle started to loosen as a result; then we'd activate the two-foot-by-two-foot elevator set up beneath each structure, which started bringing the whole thing down. We put a block of rigid foam at the bottom to keep the elevator from making too mechanical a stop—it decelerated quickly, but there was some give as it hit bottom."

Visual effects co-supervisor Ed Hirsh elected to shoot the rockfall against a real sky, so the action wound up being framed against the Berkeley hills not far from ILM, with photo cutouts of Monument Valley augmenting the natural backdrop. Complicating the tricky rigging operation, the three rock miniatures would be collapsed together during the same take. "I had thought we'd be shooting each rock as a separate element, then comping them together," commented Peterson. "The chance that all three would do the right thing at the right time—and not be ruined by a surge of wind—made the in-camera approach unlikely, but we tried anyway. The winds got really bad at one point during our testing—just as our stagehands stepped away from the structures, they started going down." On the day of the shoot, however, winds were absent, and the crew quickly captured the complex gag.

The Golden Spike ceremony at Promontory Point turns to chaos as the Tarantula gatecrashes the proceedings. "There's a shot of the two trains at this great moment in history," related Bo Welch, "and then the camera pulls back at a high rate of speed for about two hundred yards, just as one big Tarantula leg comes slamming down in the fore ground." The full-size leg, weighing eight thousand pounds and built by Michael Lantieri, represented the bottom half of a single Tarantula leg, and was hooked up to a large backhoe. "That setup let us slam the leg down really hard," explained Lantieri. "There was working piston action, plus leaky pipes that suggested a realistically flawed vehicle of the period." The real leg was used to cast shadows onto objects and performers, while also serving as reference for the ILM CG effort.

Loveless' doomsday machine succeeds admirably in disrupting the historic ceremony, but when the doctor attempts to seize the president, he finds two identical Grants, as Gordon has taken on the chief executive's guise for security purposes. Undaunted, Loveless grabs both men and lays waste to the grounds, exploding a train engine. Michael



With the abducted President Grant on board to witness, Loveless demonstrates the power of his war machine by invading the town of Silverado.



From the bridge of the Tarantula, Loveless wreaks havoc on the town in a sequence incorporating both full-size and miniature pyrotechnics.



Lantieri's crew rebuilt an old locomotive that had been trucked to the set, prepping its cab for pyro and subsequently detonating it.

From the bridge of the Tarantula, Loveless wreaks havoc on the town in a sequence incorporating both full-size and miniature pyrotechnics.

Following their capture, Grant and Gordon are brought to Loveless' lair, where West, impersonating an alluring female, manages to free his partner. Loveless, attempting to coerce the president into signing a decree of surrender that will leave the country forfeit, forces Grant to accompany him as he takes the Tarantula to the nearby town of Silverado. There the doctor's armored war machine proceeds to decimate the town while the helpless president watches in horror.

The town was called Silverado in a nod to the Lawrence Kasdan film of the same name, for which a full western town had been built in New Mexico. *Wild Wild West* was the latest in a line of period productions to shoot exteriors on the standing set, located at the Cook Ranch. Eric Brevig wound up directing much of the live-action, which required previsualizations and other preparations before he ventured to the location. "Our original Silverado animatic utilized a simple CG model of the town," said Brevig, "but to build this model accurately, we sent a surveyor to New Mexico. He got us correct placement data for all the buildings in town. That allowed us to build digital models of each structure and do low-resolution, animated journeys down each street. I cut those into a sequence that went to Barry and his editor. They made some changes, and the revised animatic became our model for building camera rigs and everything else needed for the town shots. When we finally went out on location to set up, it was like we'd already been there, because everything was just like the animatic."

A number of shots calling for tracking views level with the head of the Tarantula required the camera to be situated seventy feet above the street. "Camera cranes and helicopters couldn't be used due to the proximity of these buildings being exploded," Brevig remarked. "So we came up with a custom rig, mounting construction cranes at each end of town, then running a line between them, off which our grip crew hung a gyrosphere-equipped camera. The camera operators were well away and safe. After a few rehearsals, we found the camera could be moved at just the right speed to keep it ahead of the Tarantula we'd be adding later digitally. Since the camera and gyro made for a compact package, the odds it would experience debris hits from the exploding buildings were low. The other cameras used to cover the take would be visible in frame and would have to be painted out, but that was a small price to pay for getting the coverage we needed."

Rigging the pyrotechnics was a serious undertaking, especially since the structures were made of real wood, not balsa. "The buildings had to be laced with primer cord," said Brevig. "All the stunt people had helmets on under their bonnets and cowboy hats. The pyro events were choreographed to camera, so slotting the stunt people into the safe zones was a matter of setting them up in the proper perspective, with Michael Lantieri's guys maintaining line-of-sight to the performers as an added safety measure."

For Lantieri, the full-size pyrotechnics were an early concern. "We knew going in that exploding wooden buildings in windy conditions was a recipe for trouble," Lantieri remarked. "I sat in on preproduction meetings with the head of safety at Warner and let everyone know that we'd

burn more buildings than we intended if the winds came up. We were talking about giant explosions with hundred-foot buildings disintegrating in seconds—and this was with forty stunt people running through the streets; so shaped charges had to be used to direct the blast in front and behind these people.” Stunt coordinator Terry Leonard – who shared second-unit directing duties with Eric Brevig—and Lantieri spent a week setting marks on the street and rehearsing the routine until all the stunt personnel were ready. “Each time we shot, there’d be three buildings blowing up, and every single one of these events required thousands of feet of primer cord and hundreds of gallons of gasoline. Rigged properly, the full-sized buildings would become tooth picks in two seconds.”

The Silverado shoot took an unfortunate turn when winds did cause a pyro event to burn out of control. Desert gusts whipped the flames and burning embers onto adjacent wood buildings, and the fire soon swept out of control, decimating more than half the town. Making matters worse, the blaze occurred before all the necessary shots had been accomplished. “As a result of the fire, Silverado turned into a much bigger deal for us than anyone expected,” Jacqui Lopez noted. “After watching it burn down for hours, we were all pretty upset, but then it became a matter of salvaging the sequence. There were two concerns: one, how to use what was still there to the best possible effect; and two, determining what needed to be re-created through some other means.”

Over the next several days, Eric Brevig shot the burned-out remains of Silverado, with the Lantieri crew setting supplemental fires as needed. “Then we waited for editorial to piece it all together,” said Brevig. “When they had their cut, two full shots of the town remained missing, plus there were several others requiring supplemental burning-building elements that would have to be added as composites.” At this point, it was decided that a location miniature shoot would be needed.



During plate photography, ILM crew members utilize a partially chromed sphere and a model of the Tarantula to determine appropriate lighting for the computer generated walking machine.



When fire destroyed much of the location set, portions of Silverado had to be duplicated in miniature to complete the sequence. Modelmaker Nick Bogle assembles one of the buildings.

ILM had a good blueprint for reconstructing the town and the camera positions, based on its own animatics and footage from the abbreviated Silverado shoot. After analyzing the available data, Alex Jaeger produced a number of architectural drawings showing exactly how much of each structure would have to be built to secure the needed cuts. Twenty two- and three-sided buildings, some with just hero fronts or backs, were built under the supervision of chief modelmaker Michael Lynch. Multiple copies of cornices and facades were produced to accommodate retakes for the miniature pyro, while areas of town that would not be burned were constructed as simple miniature flats. The quarter-scale re-creation would feature intersecting cross streets, each ninety feet in length.

The materials needed to reconstruct Silverado in miniature filled a pair of fifty-five-foot trucks, which delivered the goods to Arizona, where the shoot would take place. "The main unit had shot in summer," Lorne Peterson recalled, "but by the time we arrived it was winter. Since the sun's position changes throughout the year, matching to production's Silverado footage was difficult. We ended up going as far south as possible, settling on a site near Green Valley, a half hour from Tucson and the Mexican border."

A large contingent from ILM was on hand for the three-week outing, which was complicated by concerns over the local flora. "Personnel from the state of Arizona had to locate and label each and every endangered cacti in the vicinity," remarked Michael Lynch. "Everywhere you looked, there'd be a tiny pineapple cactus with a yellow ribbon tied on. Each ribbon carried a printed warning about a \$10,000 fine for anyone who stepped on a plant, so production became insistent that we not mess with them." Some plants could be relocated safely, but the ILM crew was forced to work around others as they set to re-creating the town. Individual miniature structures were assembled as steel skeletons, which pyrotechnician Geoff Heron plumbed with propane and kerosene jets. This allowed a 'brain-flame' look to be mixed or alternated with the more traditional, black-smoke appearance associated with gasoline fires.



Modelmaker Peggy Hrastar applies final paint to another.



A crane-mounted camera was used to capture POVs from the Tarantula's bridge.

Beneath the miniature structures, grounds corresponding to those in the live-action location were required. A 'dirt library' had been started at ILM several pictures back, with jars of location dirt accompanying each location map back to the effects facility. Accurate replication of the dirt in the Silverado plates first required study under a microscope, where fuller's earth and other readily available materials were blended into a like-hued recipe. For re-creating the Silverado location in miniature, scaled dirt was fashioned from ground walnut shells, which unfortunately proved highly flammable. "A wind arose and ignited this mist of walnut shells," stated Lorne Peterson, "creating a wonderful, veil-like web of fire that didn't work for us at all. But if we ever need to create a solar flare effect, this is it - a thin, incredibly wide wall of dancing flame." The flammable walnut shells were replaced with vermiculite.

To further detail the street, Peterson attached a pair of scale wheels to a rake, which allowed him to lay down tracks for a Conestoga wagon's passage through town. Michael Lynch attached patterned sheets of plywood to the bottoms of his shoes, then stomped through the set to create impressions of tiny horseshoe prints along the streets. These hoof prints had to be re-created repeatedly, since fire control people would run down the street to extinguish blazes at the end of each take, with their out-of-scale footprints destroying the established scale. A bluescreen-seventy feet long and twenty-five feet tall-was erected to serve as a backdrop for the fiery action.

Several takes could be accomplished each day. "The action started looking better and better as we went along," remarked Peterson. "This was because we reused the charred facades, putting new facades over them. This created layers of fire-damaged texture that would be revealed during the shot. The charred pieces also didn't burn in exactly the same fashion, and that different look kept the buildings from appearing to be made out of kindling."



A shot of West and Gordon, on a flying bicycle, doing battle with the Tarantula- an image produced specifically for the teaser trailer- was so well received that it was incorporated into the film, though in an altered form.



West drops a bomb on Loveless' war machine.

Winds still proved problematic. "If gusts blew the wrong way, smoke would obscure one side of the street or the other," commented Hirsh. "So for a number of shots, we filmed the left side and the right side separately, which let us combine them without losing a lot of detail." To capture tracking shots through the miniature town, the camera was placed on a crane arm that attached to a camera car, paced to move at the Tarantula's speed. "Just after our camera car passed each section of town, Geoff Heron's guys would turn up the fire there - thus ensuring the car didn't get scorched."



Live-action for the flying bicycle sequence was photographed on a bluescreen stage.

It had been Barry Sonnenfeld's intention that a large portion of the Tarantula's march through Silverado be captured by a single, sweeping camera move covering half the town. "Barry's comic style is to get everything in one take," remarked Brevig, "but there was no way we could coordinate all of that activity. So we broke it up somewhat. Viewing the action from a side street, we see the Tarantula step on a wagon. The wagon was full-size, but the foreground buildings framing the action were our miniatures, with a CG shadow of the transport on one wall to really tie it into the scene."

After a cutaway, the camera faces the transport as another wagon - this time carrying explosives - roars across the screen and is blown up. "Believe it or not, we did the wagon pass-by in front of a blue screen in Van Nuys - just like the Washington D.C. shots," Brevig admitted. "But the camera was in motion, so we knew the Silverado background plate would end up getting match-moved to our motion control wagon foreground. We had a red rag as a marker for the motion control camera to cue from, so it would start up as the wagon entered frame." The difficulty lay with the wagon being drawn by non-motion-controlled horses. "We decided to let the horses trigger our motion control move, and set up an electric eye so when they entered frame they would break an electric beam. That sent the motion control camera into action."

After the stuntmen driving the wagon were given their cues for when to leap clear, the wagon was loaded with explosives. A static cord would stop the wagon and blow the explosives just after the men jumped off, with the front axle rigged to break at the same moment - seemingly as a result of the explosion, though in truth it was to keep the wagon from rolling over performers on the ground. "Unfortunately, the concussive force of this blast shut down the motion control computer," Brevig recalled. "At the tail-end of the shot, the camera just dived right down into the ground. But there was a lot of dust camouflaging what happened, so we were able to salvage it."

As the Tarantula stomps out of the devastated town, West and Gordon charge into battle against it from aboard a hastily concocted aircraft - thirty-four years prior to the Wright Brothers' first flight. Gordon's airborne nitrocycle was realized in both full-size and digital incarnations. "We hand-built the practical wings, including a truss that would take the weight of the unit when Tom Pahk had to hang it in front of a bluescreen," Michael Lantieri recalled. "Then we had to

make sure that when it was on location, it wouldn't try to take off when the wind got under the sail." To suggest its propulsion system, the practical nitrocycle was lit with fiery twin exhausts.

The whimsical aircraft was considered to be a major marketing element, and as such merited inclusion in a Super Bowl teaser trailer. The film's six weeks of bluescreen shooting was adjusted to include a hastily-put-together shot - intended only for the trailer-featuring the two leads on the aircraft, diving between the legs of the Tarantula. Response from the studio strongly favored the shot's inclusion in the finished film. "It was just supposed to be a grabber shot for the trailer," Eric Brevig recalled, "so continuity-wise, it didn't work with the existing cut of the film at all. Barry had switched the two actors around so that Will was now sitting in front of Kevin - and their costumes were all wrong. To top it off, Will was wearing sun glasses." By the time the decision was made to redo the shot, production was long-wrapped and the elaborate stage rig had been disassembled, requiring ILM to re-create the image completely in CG. Ultimately, a number of other bluescreen flying shots were also redone digitally.

The process involved the fabrication of CG performers. ILM already had a model of Will Smith left over from *Men in Black*, but Kevin Kline needed to be cyberscanned. "We didn't want to go with polygonal models," sequence supervisor Henry Preston recalled, "so modelers Geoff Campbell and Sunny Wei used the scan as a reference, rebuilding Kline in patches."

The fly-cycle takeoff featured a helicopter-shot background plate approaching a cliff. The CG aircraft - fashioned by Alexander Pouchkarev-sails right off the cliff, plunging earthward before Gordon is able to stabilize its flight. "The wings were set up in a couple of different ways to get that sail feel," noted Dan Taylor. "The animation controls allowed the wings and fuselage support to flex - and it was this torquing effect that conveyed the structural stresses involved." While some of the wing sails were handled like the characters' rippling clothing-through cloth simulations-much of the wing work was the result of hand-tweaked animation. Henry Preston added procedural noise to suggest the wind-ripple effect, while other controls allowed the skeletal frames forming the tail and wing to be animated in a realistic flexing action. A simple fire element in Maya duplicated the practical aircraft's twin-exhaust effect.

West and Gordon bombard the Tarantula from their fly-cycle before their craft, riddled with bullet holes, crashes into the Tarantula bridge. "Tremendous amounts of smoke and fire were used on set to show the damage that had already been done to the walking machine," Henry Preston explained, "and most of those effects had to be painted out of the shot showing West and Gordon crashing into the Tarantula. But our artists didn't just paint stuff out; they reconstructed and animated repositioned elements. Their work looked good-it needed to, because we didn't have a clean plate."

West and Gordon join President Grant as *Loveless*' prisoners on board the Tarantula in a sequence fashioned largely from shots of the actors photographed against bluescreen on the bridge set. "We needed background plates for all this bluescreen work," Ed Hirsh remarked, "so I went to Monument Valley for a week and shot rock formations from a helicopter sixty to eighty feet off the ground. There was a bit on movie film, but most of the images were stills that could be tiled together." Barry Sonnenfeld's direction for capturing the proper lighting was very specific. "He wanted the kind of rich, saturated colors you get from three-quarter front

light – no backlit vistas, which would have gone a bit purple or blue, a look he didn't favor. I found that late afternoon was best, since there are some reds in the sky, which read well against the Taran tula in the foreground."

Due to the juggernaut's awkward, mechanical gait, background images needed to move in a corresponding manner. "Repositioning the background so that the horizon changed in accordance with the walking action was tough," said Hirsh. "We needed to be both accurate and dramatic with the crablike motion. To capture this, our animators put a camera on the virtual Tarantula that let them look out at the horizon line. By running that for a bit, they'd get an idea of how it would have really looked, then took that as inspiration—a jumping-off point for the actual animation. A lot of this was subject to change, based on the lens used to shoot the foregrounds." The work was divided into left- and right-facing views, with Grady Cofer and Brian Hanable compositing the shots in Sabre.

Intent on punishing West for his intervention, Loveless confronts the agent in a below-decks area, squaring off for combat as four metallic legs deploy from his wheelchair, transforming him into a kind of cybernetic spider-man. Though the gag might have been achieved practically, Brevig and Sonnenfeld opted for a digital approach. "Attaching long articulated spider legs to an actor—on a gimbaled set that was moving all over the place—would have been completely impractical from a puppeteering standpoint," Brevig remarked. "Also, I knew Barry wouldn't want to limit himself during shooting, and this would have made the scene non-dynamic."

Simon Cheung modeled a single mechanical leg, which was replicated and repositioned to create three more appendages. Tom St. Amand and Julie Nelson were teamed to develop a style for the actual animation, aided by Dan Taylor. "Since it was part actor and part CG, we wrestled with who was going to lead this dance," said Taylor. "We thought about showing the animatics to Branagh to get his interpretation of them. But the four long legs meant the character would be making dramatic lateral moves that covered a much wider range than the actor could possibly achieve on his own—which meant there had to be some kind of rig involved."

Shoes with springs attached were considered, as was the idea of grips carrying the actor around on a stretcher. But these gimmicky solutions would create additional roto problems. "Kenneth Branagh is a remarkably good actor," stated Taylor, "so we decided to work from whatever he came up with—which, to his credit, was a really amazing-looking walk that conveyed the attitude of mechanical, spider-like legs. He did a smug little move while taunting West, and I thought we should cue off that action. He was stepping hard, exaggerating his own footfalls, so we put that same kind of energy and sense of direction into the leg, exaggerating the digital leg hits in the same hard-stepping manner he demonstrated." While the sense of character in the movement was undeniable, the dramatic range of side-to-side movement remained lacking—until John Zdzankiewicz came up with what was called the 'zig rig.' "The zig rig enabled us to see the Branagh bluescreen element displayed in Softimage, and then manipulate it in 3D space, allowing for a sliding sort of repositioning that included up-and-down movements, as well as a bit of rotation. We took his actions and just extended them, exaggerating the degree of movement by keying off his actual performance."

Wide views of West and Loveless during the scene were handled as composites, with empty plates filmed on set and the actors photographed in separate bluescreen passes. "Charles Schumann, our bluescreen DP, paid a lot of attention to interactive shadows," Brevig explained. "Coupled with continuity of color and quality of light bleeding into the set, this helped make the blue screen cuts indistinguishable from non-composites in the sequence." The bluescreen work resulted in plates so clean that little plate restoration was required. After extractions were performed on Branagh's blue-stockinged legs, only a straight dividing line for the box around the actor's waist remained, beneath which the CG legs would unfold.

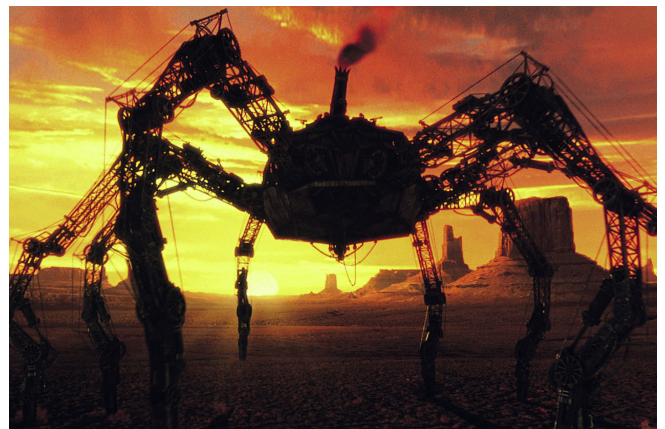
For many cuts in the sequence, an empty plate image of the set was wrapped around a sphere to provide an environment map for the CG legs. "The parts of each leg that faced outward got the map," stated Henry Preston. "Interior leg surfaces were handled differently, in a couple of ways. We used RenderMan's simple reflections, plus a ray-traced matte pass that darkened those surfaces. Elbert Yen's paint job added bump-mapped rivets to the mechanical legs; and then we broke up the high lights by throwing in specular lights."

During the confrontation with the now ambulatory Loveless, Gordon fires a shot that creates a hydraulic fluid leak in the doctor's mechanical support. He soon finds himself on the floor as all four of his spider legs fail him, first going limp and then falling off. "Tom Fejes and Hilmar Koch did some excellent TD work on this sequence," noted Preston, "matching the CG legs to the prop legs seen lying on the deck in later shots."

With the Tarantula marching toward a cliff on autopilot, it seems all aboard will be lost. Loveless opens fire on West and misses, inadvertently damaging his transport, which grinds to a halt. On the brink of a four-hundred-foot fall, the huge transport teeters wildly, causing all aboard to lose their balance. In the original cut of the film, Loveless fell to his death after sliding out of the belly of his beast. But this ending was to be embellished shortly prior to the film's release.

"Barry tested the movie for an audience in April," Jacqui Lopez noted. "Based on those results, he decided to do some reshoots in order to emphasize the film's humor." Sonnenfeld also elected to add the pre-title decapitation scene, plus new shots for the film's climax. "These two scenes required fifty new visual effects shots, but because our techniques were well-honed and Barry trusted us, we were able to take them on during a three-week period just prior to release."

In the revised ending, both Loveless and West wind up dangling from the Tarantula, hundreds of feet above the valley floor, with the former hanging onto a ledge and the latter clinging to his adversary. After exchanging taunts, both men fall - but West saves himself from a fatal plunge by grabbing hold of a corpse suspended beneath the transport. The dead man, a character known as 'Knife Guy' for the blades he sported on his person in place of more traditional



Having vanquished the enemy, West and Gordon ride off into the sunset aboard the Tarantula.

appendages, was newly created for the reshoot. He and several other Loveless henchmen would battle with West aboard the Tarantula in an earlier scene. "The big fight was added as a result of the audience screening," stated Brevig. "Several viewers thought West, Gordon and Grant fighting only Loveless' bevy of beauties seemed a bit odd." While besting this mutated wild bunch, West would loop a chain around Knife Guy's neck and throw him overboard, hanging The Man--and establishing a convenient form for West to later grasp.

Knife Guy, along with Loveless' other hench-men, were all previous subjects of the doctor's experiments, appearing as twisted crosses between the unfortunates of Dr. Moreau and flesh-metal fusions reminiscent of cyberpunk and Star Trek's Borg. Cinovation was again called in. "Barry asked that we come up with makeups for these characters within the week," said Rick Baker, "so there wasn't much time to play around with the concepts. Producer Jon Peters insisted we include one guy who was scarred and missing an eye, so we did that for him. We only dirtied up Knife Guy, then created another henchman with a metal plate bolted to his skull. There was one we called Spike Guy, who had a spike driven through his head. I did a design on the computer for him that featured a whole bunch of spikes instead of a single one - it was kind of Christ-like, with spikes driven through his head in a crown-of-thorns kind of pattern. That turned out to be a little too wacky and insane, so we backed off - these guys were really just supposed to be local color."

The reshoots and story changes affected a number of previously finalized effects shots. "We had to revisit some shots of the transport's march toward the cliff," sequence supervisor John Helms stated, "since the dead hanging form of Knife Guy had to be plugged into all of those shots. We had already developed CG figures for the aircraft scenes, so creating the dangling figure wasn't a major investment." Additional background plates were captured on a return trip to Arizona. "There was a combination of stills mapped onto CG geometry and tiles for the backgrounds."

A western is a western is a western, and gadgets notwithstanding, Wild Wild West was no exception. The film's final image, like that of so many horse operas preceding it, captured a dramatic sunset -though this one was occluded by the Tarantula as it clanked off into the distance.

While computer animation provided an ideal means for capturing the Tarantula, the completed film reflects a hands-on physicality that greatly enhanced the sense of epic sprawl inherent in the western genre. "From a standpoint of mechanical effects, this was as big as anything I've ever seen," Michael Lantieri asserted. "Not only did everything have to work; in order to make the comedy succeed, it had to work on the right beat. The performance aspect of our work, making it all happen to these specific Barry Sonnenfeld timings, added a whole extra magnitude of challenge, and made Wild Wild West into something truly memorable."

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THE HOUSE THAT ROARED

ARTICLE BY CHRISTINE SANDOVAL



The first line in Shirley Jackson’s novel, *The Haunting of Hill House*, claims that “no live organism can continue for long to exist sanely under conditions of absolute reality.” Robert Wise, in his black-and-white 1963 movie based on the book, *The Haunting*, explored the idea of humanity’s need to dream and imagine, even if those dreams might, in fact, lead us to frightening places. With nothing more than tricks of light, sound effects and creative camera angles, Wise created an eerie realm where the lines between fantasy, reality and horror were alarmingly blurred.

In DreamWorks’ new incarnation of Jackson’s classic tale, director Jan De Bont again encourages us to question our notions of existence; but this time, rather than relying on the most subtle of filmmaking tricks to create a mood, the film takes us out of that realm of “absolute reality” through hard-hitting, high-tech effects contributed by Tippett Studio, John Frazier Special Effects, KNB EFX Group and Industrial Light & Magic.

Like the original, the new film revolves around the character of Nell (Lili Taylor), a sheltered young woman who has spent most of her adult life caring for her elderly, bedridden mother. After her mother dies, Nell yearns to escape her narrow existence and, toward that end, agrees to participate in what she believes to be a sleep disorder study, conducted by psychiatrist David Marrow (Liam Neeson). Also taking part in the study are Theo (Catherine Zeta-Jones)– a woman as worldly and sophisticated as Nell is naive– and the irreverent Luke (Owen Wilson). This core group gathers at an abandoned and reputedly haunted mansion, called Hill House, where Dr. Marrow actually intends to study the effects of fear and its impact on group interaction. But the suggestion of fear becomes all-too-real terror as the house itself– a house with a terrible secret– seems to claim Nell for its own.

While some of the ghostly goings-on would be achieved in-camera, with the help of gags rigged by John Frazier’s special effects unit, most would fall within Phil Tippett’s CG domain. At the start of the short two-and-a-half-month preproduction, Tippett and De Bont analyzed the project’s visual effects shots, which would range from the subtle, did-we-see-that-or-didn’t-we type featured early in the story to fully-realized apparitions at the film’s climax. ‘The effects

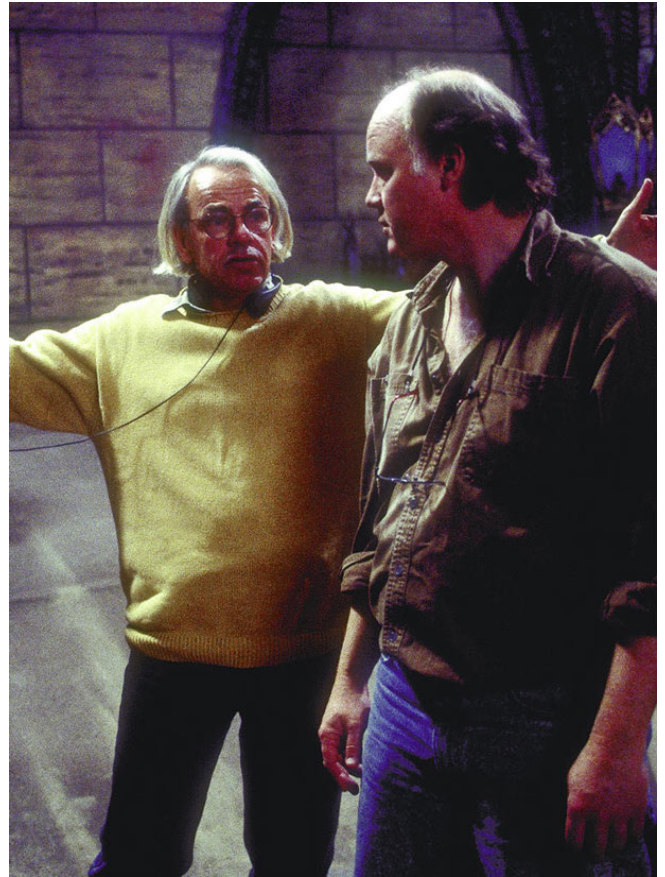
basically broke down into two different ideas,” Tippet explained. ‘One was that these things were actually hallucinations- manifestations of Nell’s unstable mind. The other group of effects would make it clear to the other participants in the experiment that the house really was trying to claim Nell.”

The driving spirit behind the malevolent house is its builder and original master, Hugh Crain- a rich and powerful man who slaughtered dozens of local children within the walls of Hill House. Jan De Bont considered the house itself- imbued with the spirits of both Crain and the murdered children - to be his movie’s main character. That character would be realized, in part, through exteriors shot in Lincolnshire, England, where a suitably strange and eerie-looking mansion was discovered. But the essence of Hill House would find expression most prominently in the grand and elaborate interior sets constructed on stage at Raleigh Studios and at the former Spruce Goose dome in Long Beach by production designer Eugenio Zanetti. Zanetti- who had worked with De Bont previously when the director had served as cinematographer on Flatliners - had won an Academy Award for his work on Restoration and recently been recognized with a nomination for his lush production design for What Dreams May Come.

In early discussions with De Bont, Zanetti expressed his vision of The Haunting as a metaphysical horror movie with similarities to Citizen Kane. ‘Xanadu in Citizen Kane is a house that represents Charles Foster Kane,” Zanetti related. ‘It is, in fact, that man. And that man is, in some ways, a monster. The same was true of the house in The Haunting. As I studied the script further, I began looking for what this movie was about- not the plot, but what it was really about. And I realized that what it was about- at least for me- was a woman who’d had a very unhappy childhood. She goes from this miserable, depressing little apartment where she has lived with her mother all her life directly to this fairytale-like, beautiful house. And that makes it seductive to her. For Nell, Hill House is a fabulous place- a place she and Theo explore much like Alice explores Wonderland.”

Expanding on the idea of Alice in Wonderland, Zanetti decided that mirrors would play an important part in the design of the sets. 'It was Alice in the Looking Glass,' Zanetti commented. 'The idea of mirrors became very important. I created, for instance, the mirror room, which I wanted to shoot with the camera panning all around. I went back to Busby Berkeley movies of the thirties, which had used this idea, and I learned that they had built a set of mirrors on a turntable- that way, the camera could remain static while the room rotated. Obviously, you can't pan on a mirror room because the camera will be visible in the shot. But if the camera is hidden in a hole, and it remains stationary as the rooms spins, then it works. So I built that, and it turned out to be a beautiful set, like a gigantic music box.' Mirrors also figured prominently in a corridor scene in which Nell and Theo see infinite reflections of themselves- another shot inspired by Citizen Kane.

Both story and dramatic considerations mandated that Hill House be a structure of the Victorian period- an era known for its architectural and design eclecticism. 'The Victorians put together, in an undigested way, styles from all over the world,' Zanetti observed. 'That was good for us because a house made up of many different styles suggested a deranged personality had created it. It worked not only from a historical sense, but also in indicating the personality of Hugh Crain.' To support the house-as-extension-of-its-master idea, Zanetti designed the rooms to suggest a human body. 'In the center is the red parlor, and that is the heart of Hill House. From there, it expands with a system of veins- all of these enormous, curved hallways and corridors, which also act as arms. And, finally, there is the fireplace, which is the face and the mouth that essentially devours these children. I put a gigantic sculpture of lions above The Mantle, which looked something like eyebrows, and two lamps that looked like eyes.'



Director Jan De Bont discusses a scene with visual effects supervisor Phil Tippett on the set of the supernatural thriller, *The Haunting*, about a group of insomniacs unwittingly made the subjects of a psychological study relating to fear and its effect on group dynamics.

Other expansive and intricately detailed sets included the great hall and stairway, multiple bedrooms, a library, and the greenhouse where Nell, in a kind of trance, comes close to reenacting the hanging suicide of the first Mrs. Crain. In both scale and complexity, the design and building of these sets was a daunting endeavor, made even more so by excruciating time constraints. "This film should have had a year-and-a-half-long prep," remarked Zanetti. "But we had only eight weeks in which to design and build everything. Nothing at all existed for the movie. Everything had to be designed and built from scratch- and to do that took an enormous effort. I had forty sculptors working in three shifts, day and night. I had three hundred painters working day and night. It was crazy." In addition to the rooms themselves, all of the elaborate ornamentation featured in the house- moldings, carvings, statues, paintings and brass work- had to be created from scratch. "And none of this stuff could be cheesy or movie-style. It all had to look good and it all had to look authentic. In most movies- *Gone With the Wind*, for example- the portraits on the walls look very cheesy. But the portraits in this film looked authentic, and were even aged to look old. Creating all of these sets and set dressings in so short a time was a huge achievement."

Among the most crucial design elements were the carved wooden cherubs seen throughout the house- sculptures that represent the lost children of Hill House. Since the sculptures would change expression through computer animation, Zanetti ran his cherub designs by Phil Tippet to ensure the concepts would work from a visual effects standpoint. "We designed and created each stage of the cherubs' expressions," explained Zanetti, "such as serene, surprised and afraid, and then the visual effects people connected those stages." That kind of in-tandem approach had to be taken with nearly all of the sculptures in the house- such as figures in the greenhouse fountain, the



Hill House- whose interiors were created on stage by production designer Eugenio Zanetti- was conceived as a character in the film and an extension of its original owner, a deranged multimillionaire industrialist who murdered dozens of children on the site.



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fireplace lions and the stairway griffins- since each would “come to life’ at some point in the film. Zanetti also worked closely with the animatronics crew- which would articulate more simple movements of the statuary- to determine what designs and materials would best serve mechanical considerations.

Though Zanetti’s creations would set the off-kilter tone of the film and establish the character of Hill House, real life- manifested in an erupting, malevolent fireplace, animated statues, and ghostly Crain and child entities- was not breathed into the fictional structure until the digital team at Tippett Studio had realized its array of visual effects. While collaboration between the effects team and art department is typical, the intensely symbiotic nature of the effects and production goals in *The Haunting* demanded virtually parallel efforts. “There was tremendous interaction between us,” said Tippett. “We had a production meeting every week where we would all come together- Eugenio, art director Tomas Voth, John Frazier, director of photography Karl Walter Lindenlaub, myself and Craig Hayes, my partner- everyone was there. At the time we only had the screenplay, and Jan was still busy developing the storyboards. Then, once there was a clear set of storyboards, we all sat down and figured out what was going to be done practically, and what was going to be done by us.”

The primary digital effects task was creating the Crain and child entities- characters for which there were no real-life references. “With a bug or a dinosaur,” noted Tippett, “we are dealing with a known entity. There is a model out there in the real world that we can check ourselves against. That wasn’t the case here. With this show, we were developing a horrific character for the house itself and *The Manifestation* of the spirits that live within. But “horror’ is very subjective. What makes something creepy? Everybody has a different opinion on that. What I think is creepy may be different from what Jan De Bont thinks is creepy. On top of that, we were trying to walk a line between something that existed in Nell’s mind and something that existed physically. We wanted these images to come and go, without letting the audience ever get too clear a fix on anything. All of these things- the level of manifestation, the definition of “creepiness,’ the balance between reality and nonreality- had to be decided on a shot-by-shot basis.”

Completing the effects was a race, from the start. On the heels of the ten-week preproduction came a seventy-day shoot and a four-month postproduction- a total of nine months from greenlight to release. Adding to the pressure was the fact that many of the digital tools the project required were not yet in place when Tippett and company took on the assignment. “There was a lot of new technology that we needed to develop in order to complete the show,” stated Tippett. “It was all very process-intensive in that it took so many steps to achieve a particular effect. Sometimes it took months to complete an element.”

Craig Hayes, co-visual effects supervisor and longtime Tippett associate, stayed at the Berkeley-based Tippett Studio to get a jump-start on the development of tools and specific shots, while Tippett himself was with the production crew in England and Los Angeles to lend guidance in the shooting of effects plates. Also on the set was John Frazier, whose unit would provide pyrotechnics, practical rigs and other on-set effects.

Among the first signs that something is amiss at Hill House are The Many carvings and statues of cherubs, whose eyes seem to follow Nell as she explores the house and moves from room to room. These first subtle effects were the work of KNB EFX Group, which provided animatronics for the initial cherub movements. ‘We got a call from the production,” said KNB supervisors Greg Nicotero, ‘saying that they had these “trptychs”- decorative sculptures- of cherubic baby faces, and they wanted to do some tests to see what kind of movement they could get with radio-controlled versions. There were plans to do the more complicated shots digitally, but some of the movements were going to be very slow and subtle; and since Phil Tippett was already tremendously overloaded, Jan wanted to utilize tried-and-true animatronics techniques, if he could.”

To start, Nicotero and his team acquired copies of the cherub faces- built in groups of three- from the production art department, then molded and cast them in silicone to create heads which could be radio-controlled to move from side to side. ‘At first,” commented Nicotero, ‘they wanted all three heads to move at once, but we ended up making them so that they could move independently.” The movements of the heads were understated to the point of being barely noticeable. “This was early on in the film, when Nell is just getting settled into her bedroom and going to bed. At this point, we didn’t want the audience to be sure if something supernatural was happening or not; so it was subtle.” The effect is even more understated in the final version of the film, in which the actual articulation of the cherubs goes unseen by the audience. Rather, the cherubs are seen facing one direction at the start of the scene, then another in following shots.

Nell first becomes aware of the spirits as she sits at a bedroom vanity, combing her hair. Invisible hands cause the comb to part the hair, then spiral it up into a French twist- a style favored by Crain’s deceased wife. The initial parting of the hair was accomplished by carefully blending CG elements with plate photography of Lili Taylor’s real hair. ‘We had a side view of her combing her hair on the set,” noted Craig Hayes. ‘Through a 2D process, we were able to take that image and pull it apart, literally stretching it like fabric to create the split. Then we darkened that area and created an impression of depth with successive layers, just working on top of the plate.” To align the 2D imagery to the live-action, the crew executed a 3D track of the actress’ head in the plate. ‘We had these grids on her head, and from those grids we were able to generate the information we needed to warp the plate.” To give the image more character and realism, individual fly-away hairs were modeled in 3D.

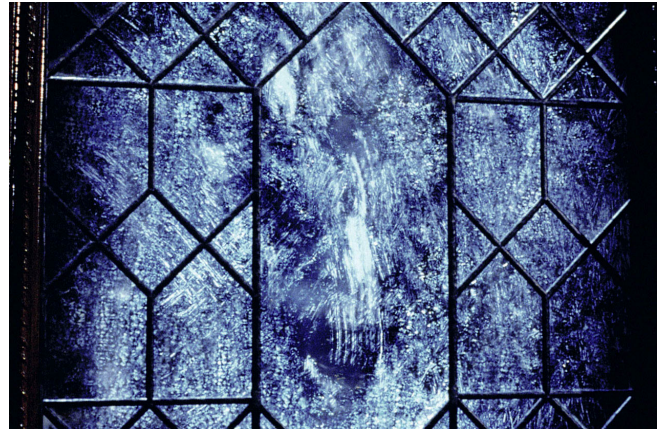


In a CG sequence created at Tippett Studio, the spectral form of a ghost-child appears in the folds of a curtain and then slides beneath the sheets and pillowcases of the bed in which Nell (Lili Taylor), one of the study subjects, is sleeping.

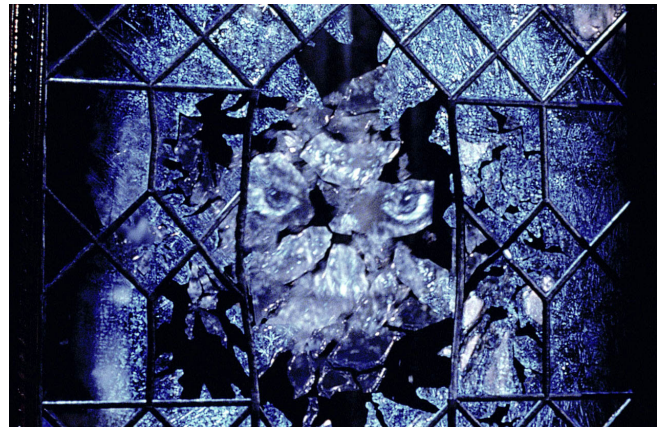
The following shot, in which the hair twists up into a knot, was more complicated. "The hair had to move in a very specific way," stated Hayes. "Unlike animal fur, which pretty much just moves with the animal, this hair had to deliver a performance." Taylor's real hair was gelled back for the live-action photography, enabling the Tippett artists to create a completely CG scalp and head of hair. "We built a scalp model from a scan of Lili Taylor's head, and populated it with CG hair. The tough part was getting it to look exactly like her hair in the previous shots." Scott Souter was responsible for creating the virtual wig, made up of approximately forty splines, each of which featured a large number of individual hairs. Those splines were then animated by Rob Skiena and Eric Reynolds to twist about and form into the desired knot.

The house spirits up the ante when a ghost-child appears within the folds of Nell's bedroom window curtain, then slides under the satin sheet and pillowcase on the sleeping woman's bed. Craig Hayes and his team initiated the creation of the effects sequence by digitizing one of Eugenio Zanetti's cherub sculptures. "There was discussion of digitizing a real child," Hayes remarked, "but Jan De Bont was looking for a high level of stylization. If we had digitized a real child, we would have had to mess with that image so much, we wouldn't have gained anything by going that way- and frankly, it wouldn't have been appropriate, due to the kinds of movement the ghost-child performs, especially in this sequence. They're not human-like movements, they're ghostly movements."

Once the cherub sculpture had been digitized, producing a rough ghost-child model, animation supervisor Blair Clark and his team worked out the broad-strokes animation and general timings for the character. The look was finessed in a second animation pass. "Those shots were difficult," Clark recalled. "Todd LaBonte animated the first shot to look as if the ghost-child was sliding down a waterfall as it appeared and moved down the curtain, and Robin Watts animated the shot of the child slithering under the satin sheet. Because our production time was so short, we had several people working on shots from that sequence simultaneously, and they did a great job."



The visage of Hugh Crain- the long-deceased owner of Hill House- appears in a frosted window which, when broken by Nell, implodes in a blast containing hundreds of CG glass shards.



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In the rendering phase, CG lighting supervisor Julie Newdoll and her crew were careful to light the figure so as to give it the impression of benevolence. ‘Most of the characters in this movie were horrifying,” Newdoll observed, ‘but the ghost-child had to appear somewhat angelic. I did some charcoal sketches of faces under different lighting situations to help my team discover and realize the ghost-child’s personality.”

The sequence also required the re-creation, in CG, of the live-action curtain, bed sheet and pillowcase. Effects animation supervisor Eric Leven and his team first researched existing cloth simulation software packages, but- disappointed in the state of the art- determined a better solution could be developed in-house. ‘It is typical for our company not to use off-the-shelf stuff anyway,” commented Leven. ‘We’re a bubble-gum-and-duct-tape kind of company. We ended up using Dynamation as a basis, then writing some of our own stuff to make it work for the cloth.” Creating a photorealistic look for the satin sheets and pillowcase was particularly challenging. ‘Satin was the hardest material to animate, because it had to ripple in a very specific way as the child moved beneath it.”

To marry the ghost-child animation with the computer generated curtain, a measurement was taken for each frame to determine how far the apparition’s face would extend from the surface of the flapping curtain. ‘We applied those measurements to the CG curtain and bulged it out accordingly,” stated Hayes. ‘That gave us a curtain with a shape applied exactly where the child would be. It was the opposite of draping a curtain over a shape- we determined what the shape would be and applied that shape to the curtain.”

In this and other scenes in which spirits are manifested, an isolated rush of cold air permeates the area, creating breath vapor as characters talk. Rather than attempt to produce real breath vapor by shooting on a refrigerated stage, the filmmakers opted to effect it digitally.

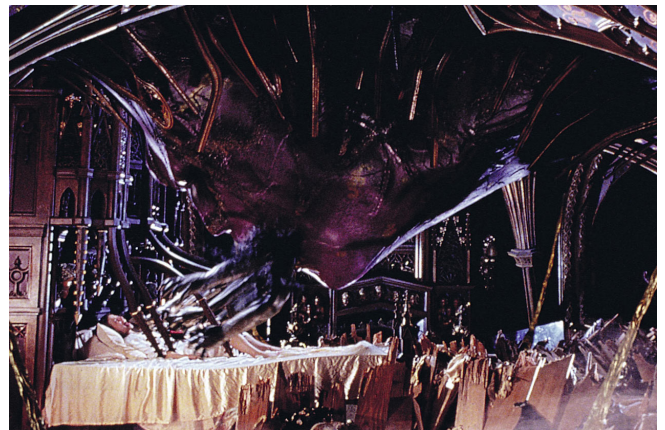
Compositing supervisor Brennan Doyle was among those at Tippett Studio who found himself carefully watching the breath vapor emanating from co-workers’ mouths as they talked in the cold outside the facility. ‘We went out with a video camera one night,” stated Doyle, ‘and shot people talking against a black background, a bright-colored one, a gray background, et cetera. We wanted to see how the color of the background plate would effect the look of the vapor.”

Vapor textures were created with particles in Dynamation. ‘The particles were basically a bunch of little painted puffs of smoke,” Doyle explained. ‘They were applied to a grid, and the effects animators would define the rules as to when those grids should appear or disappear, and how they should move once they were visible. So it was mostly code-based, with mathematical algorithms generating the images.” The test video provided the animators with good reference as to how much vapor would be visible, how fast it would move, and how far it would travel before dissipating. ‘After we animated each breath effect,” elaborated Eric Leven, ‘we could go back in and tweak it a little, turn it on here, off there.”

Effects animators would get each breath vapor shot about fifty to sixty percent of the way, then the compositors would light it to take the shot to final. Lighting in the composite stage, rather than taking each shot through the traditional pipeline of animation to rendering, was a cheat that enabled the Tippett Studio to expedite its considerable number of breath vapor shots. ‘Lighting all of these shots in the comp was a big challenge,” remarked Doyle, ‘which we accomplished several different ways. We got one interesting lighting effect through offsetting. We’d duplicate the element of the person breathing, for example, offset it and use that to create a rim around the original element, a tinted edge. By cutting just that little rim area of the offset element and brightening it, we could use it to create a brighter halo effect around the original element.” In many cases, the compositors would fade the breath so that it would not become visible until it reached a certain distance from the mouth of the speaking character. ‘We found from our reference that there’s a little bit of breath that comes out at first and at the end- but in the center the breath is really heavy. So we would take the breath element, offset it in time, and then build it up to make it look like the center was denser than the edge.” Details that sold the breath vapor shots, also added by the compositors, were shadows cast from the vapor onto faces and rotoscoped hands pass-ing through the vapor trail.

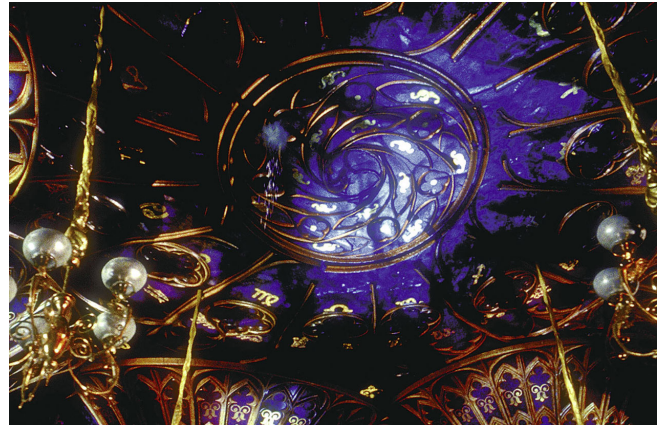


A massive fountain statue in The Mansion’s eerie greenhouse reaches for Dr. David Marrow (Liam Neeson) and drags him into the water.



For a sequence in which the house attempts to possess Nell as she sleeps, practical and digital effects were combined to produce shots of the terrified woman pinned to her bed as the room’s walls close in and the Hugh Crain entity takes form in a stained-glass skylight overhead.

The frigid temperatures that cause Nell and the others to see their own breath also enable Crain to create an image of himself in the condensation on Nell's bedroom window as the woman sleeps. "This was the point in the story where we really had to start illustrating Crain," related Hayes. "We had to come up with a stylistic look of an image formed out of condensation or ice crystals on the interior of a window." From a head scan of actor Charles Gunning, the Tippett crew built a digital model of Crain that was used in conjunction with a particle system to create the ice-crystal image. "We took our 3D model and placed it so it looked as if it was outside the window. Then we rendered that image and combined it with particles, using those particles as a way to reveal the Crain image in the glass. We animated the particles so that it looked like a big exhale, with frost filling in to form the image. We also utilized some particles to do crystalline growth on the window, with ice crystals cracking and fragmenting."



For a sequence in which the house attempts to possess Nell as she sleeps, practical and digital effects were combined to produce shots of the terrified woman pinned to her bed as the room's walls close in and the Hugh Crain entity takes form in a stained-glass skylight overhead.

When Nell awakens to find Crain's image in the window, she jumps out of bed, grabs a music box and throws it, shattering the pane of glass. Unlike the Crain-image window shots- in which an on-set window was enhanced with digital elements- cuts of the window exploding into hundreds of shards of glass were completely computer generated. "We built one window that was an exact duplicate of the practical leaded glass window on set," said Hayes, "complete with little soldered joints and other details. Then we took that same window and broke it up into hundreds of fragments. The two windows- practical and CG- were aligned so that we could cut from one to the other just prior to the window exploding out."

To create the exploding, eight-hundred-piece window, Eric Leven again checked out off-the shelf software, but none worked to his satisfaction. "We ended up writing our own stuff," stated Leven. "It was totally low-tech, but totally cool. We used Dynamation particles and actual geometry, animating specific pieces of geometry to rotate and fly out." Complicating the animation was the fact that the scene appears to have been shot at three different film speeds: the music box flies through the window in approximate real-time; then the glass breaks and the action slows to slow-motion until the window fragments begin to reverse direction and explode inward at yet another film speed. "One of the reasons we did the window entirely in CG," remarked Hayes, "was so that we would have control over the timings and apparent film rates."

The spirits of the dead children finally lead Nell to the ashdrop of the huge fireplace in the great hall. Compelled by the spirits, she digs through the ashes with a fireplace poker and discovers both a child's skull and the skull of Hugh Crain. While she is still reeling from the implications of her horrific find, a skeleton erupts out of the ash and grabs her. For the effect, KNB built a fully articulated skeleton puppet, which was buried beneath the ash. "Three puppeteers were under the floor to raise the body with the help of a fulcrum," related Greg Nicotero, "which,

when the bar was pulled, would raise the skeleton up at the waist.” Other puppeteers were on hand to raise the arms of the skeleton through cable mechanisms, while cables also enabled the head to move in four different directions.

In terror, Nell runs through the house and ends up in the greenhouse where Crain’s first wife hung herself from the top of a spindly double-helix staircase. Finding Nell perilously perched at the top in a trance-like state, Marrow begins to go after her, the staircase shaking and falling apart as he ascends. John Frazier fashioned the thirty-foot-tall staircase, which was part of the greenhouse set erected in the Long Beach dome. The double-helix design– two spiral cases winding around one another– required that the construct be hung by cables. “The staircase was actually a bunch of separate pieces that were held in place by half-inch cables coming up through the set,” Frazier stated. “Those sections were cast out of aluminum and hung on cables that could be triggered to release a specific piece on cue. We used cable cutters to collapse each section of the staircase as Liam Neeson climbed the thing. There were also cables extending out the back, where we had a crew of guys manipulating them to shake the staircase. Any cables that were in the frame were painted out digitally.”

A centerpiece sequence– and the one featured most extensively in the movie’s trailers– is one in which Nell’s bedroom seems to come alive to take the young woman captive. The bedroom walls close in around her, the ceiling lowers, and decorative tendrils on the headboard of her bed pin Nell’s arms and legs as Crain’s visage appears above her. Though most of the sequence would be computer generated, some elements would be captured in-camera. Keeping effects concerns in mind, Zanetti designed the octagonal bedroom as a large, Gothic enclosure with stained-glass skylight and heavily carved palmettos adorning the walls. “The reason for the palmettos was that we knew the room was going to collapse, as if it was closing in on Nell,” Zanetti said. “The palmettos provided “hands’ that could be lowered into the room, making it look as if the walls were closing in.”

John Frazier built twenty-foot-tall palmettos– one for each of the eight walls– out of fiberglass, with steel armatures inside. To make the decorative wall panels lower into the room, each palmetto was rigged with a hydraulic ram connected to a waldo– a miniature, computer-linked version of the armature– and controlled by a single operator. “Our guys would move the waldos manually during rehearsal,” noted Frazier, “and each move would be recorded in the computer. Then, when the camera was rolling, all we’d have to do is press a button to repeat that programmed move exactly.”

Nell’s bed also seems to come to life, moving suddenly to the center of the room as snakelike tendrils emerge from its headboard. KNB contributed animatronic tendrils– later enhanced by the Tippett crew– working closely with John Frazier’s team. “John built the bed with a hydraulic piston in it so that the carriage could slide up and down,” noted Nicotero, “and then we made eight tendrils that went inside the carriage. Air cylinders lowered the tendrils. At the tip of each



was a four-way cable mechanism that would move the tendrils like seaweed underwater. As the carriage began to lower, the tendrils dropped down and moved as if they were reaching for Nell."

When the others enter and find Nell pinned to the bed, Luke grabs a candelabra and splinters the tendrils to free her. For the scene, pieces connecting the tips of the tendrils to the bed were molded out of thin, breakable fiberglass by KNB. 'De Bont was very, very specific about this scene,' recalled Nicotero. 'He told us the breakaway tendrils could not look like balsa wood or any other weak wood or material; they had to look like strong wood breaking.' KNB prescored the hollow fiberglass tendrils and placed woodchips in the center so that when Wilson hit them with the candelabra, realistic wooden debris would explode outward.

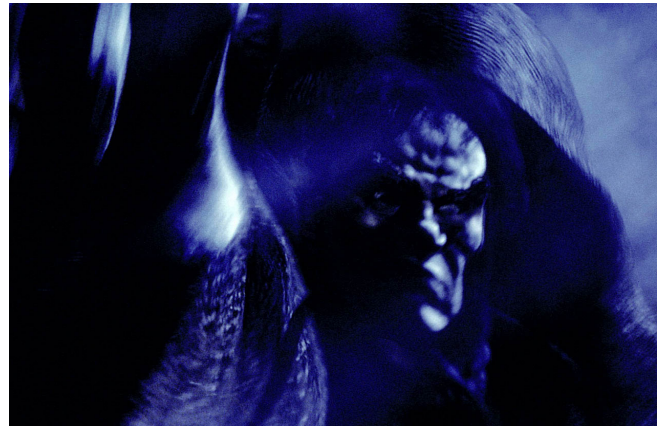
While all of these practical effects brought a degree of mayhem to the bedroom implosion scene, the horror was magnified with computer generated effects that suggested additional room destruction and the appearance of the Crain entity in the ceiling. The sequence was such a complex one for the digital team that Tippet put animators on the task of creating an animatic for the scene early in the preproduction phase. 'At that point,' said Tippet, 'it was unclear as to how much of this sequence would be computer graphic and how much could be practical. So we mocked up the sequence in the computer and ran the entire thing from two different angles, trying to previsualize the problems we would be getting into.'

Eugenio Zanetti's department had considered a great number of concepts for the Crain entity as it appears in the ceiling of Nell's bedroom. 'We went through a lot of different ideas,' explained Zanetti. 'One idea was that the Crain entity would be made up of many different bodies. We had many meetings to discuss these ideas; but, in the end, it was Phil Tippet who really shaped the final image, based on the portrait of the character you see in the house.'

'There's a clear arc to how Crain manifests himself,' Tippet noted. 'He starts out very indistinct, but as the movie goes on, he tries to manifest himself, as if he's crawling out of the primordial ooze. So you see a bit of a suggestion of him at first, but you don't have any idea that it is Crain. As he is seen in the painting on the wall, Crain looks like a cross between a wolfman and Charles Gunning, the actor we digitized and used for the basis of our CG character.'

Time restraints made it necessary for all of the Tippet departments to work on the Crain entity in Nell's bedroom simultaneously, resulting in a nonlinear style of production. 'In the past,' observed Brennan Doyle, 'we've worked in a very linear fashion, with the animators animating

Artists at Tippet Studio built and animated digital models of numerous statuary set pieces that come to life within the haunted house.



The Crain entity becomes increasingly human in form as the film progresses. In its final scenes, it is a totally CG figure— a stylized representation of the actor who was cyberscanned as a basis for the character— created by Tippet Studio.

something, then the TDs lighting it, then it being handed over to the composers, who put it all together. But with this sequence, the animator animated a grid, which was the basic surface of the ceiling. Then the technical director created displacement maps to perturb the surface of the flat grid to match the face. So we had a flat grid with a face poking through it, and from that we generated a gray-scale image that defined the distance between the flat grid and every point on the face. That was given to the composers to blend its edges. Then it came back to the animator who would animate on top of that. We were all involved in the process of creating that imagery.”

Building upon the image of Crain as depicted in the window-condensation scene earlier, the departments strove to reveal more of Crain’s features in the bedroom ceiling, but still hide enough to leave much to the audience’s imagination. A sense of mood and mystery was also heightened by the lighting. ‘In the Nell’s bedroom scene,” explained Julie Newdoll, ‘we could do whatever we wanted in the lighting. We had to make it look moody, but we had a lot of freedom to put expression on this guy. Since he had to look really angry and scary, we highlighted his brows and used what is called “monster light,” where the light comes up from below. We also painted in a lot of cutters– the digital equivalent to putting a gobo on a set light to create patterns. We ended up with some really wild patterns of light and shadow on his face– and if it still didn’t look angry enough, we’d paint something to enhance it.”

As the Crain entity pushes down from the ceiling, the wood on the walls and floorboards begins to splinter and erupt with the pressure. ‘To create the destruction,” explained Tippet, ‘we attempted to work within what we understood the materiality of the house to be, what it was made of. We didn’t want to do a morph or some other rubbery-looking computer graphic thing. If the floorboards began to rip up, we wanted it to really look like a physical thing, showing the wood and the concrete foundation and all the other materials out of which the building was actually built.”

For the erupting floorboards, digital painters scanned wooden planks to create realistic texture maps that could be applied to 3D geometry. ‘We utilized Photoshop, Practical Design Painter and Amazon 3D Paint,” recalled Craig Hayes. ‘But even with those tools to create good texture maps, the look depended on the skill of our painters. It still required that artistic eye.”

Geometries were also created to replace about twenty-five percent of the furniture in the room, so that it could be animated to fly through the space as needed. Chandeliers were animated to swing through the frame at any given point. Added effects animation included particle-based dust and debris.

In a scene following Nell’s rescue from the Crain entity, Luke is decapitated in the great hall fireplace by a huge lion’s head flue that seemingly comes to life. The gag was made up of practical effects and Tippet Studio digital creations. KNB supplied a decapitation puppet, produced from a cast of Owen Wilson from the waist up. ‘We rigged the puppet with a pin that went up inside the head and came out the neck,” Nicotero explained, ‘so on “action” we would pull out the pin and the head would roll off.” KNB also provided the aftermath figure of the decapitation. ‘We had a full-body dummy that was jointed. It would fall to its knees and then down on the ground next to the decapitated head.”

At Tippett Studio, artists matched the lion's head flue built for production, doing some quick on-site scanning of the practical model. 'While shooting the scene,' Craig Hayes noted, 'we had a big inflatable ball on a stick to use for timing and to give Owen Wilson something to react to. The big ball would swing out and hit him in the head and he could pretend he just got his head cut off. We then painted the ball out and painted his head out. At the exact frame where the head is supposed to be bitten off, we started painting the background plate through on top of that, meticulously carving out his head and replacing it with background. We also built a CG model of his cranium so that there would be something in the lion's mouth.' In a brief cut, the audience sees the CG image of Luke's head in the lion's mouth, its hair mangled and bloody. In the next shot, the decapitated corpse falls to the ground, the flue drops open, and Luke's head—a practical piece—falls out.

The house's fury mounts as the fireplace hurls forth the skulls and bones of dozens of murdered children. John Frazier's team filled air mortars with rubber skulls and bones—provided by KNB—and at the flip of a switch, the human remains came spewing into the great hall. 'We molded an actual skeleton and ran different colored bones,' Nicotero said, 'since the bones were supposed to be burned and old and aged. We made soft bones and semi-rigid bones, so that if somebody were to step on them they wouldn't look like rubber.'

Crain's heightening rage reveals itself as the house's statues and carvings come to life. On-set versions of the various statues—such as the lion, ram and griffin statuary—were digitized, and that raw data was used as a starting point for building computer models. The digital approach was a labor-intensive one, especially considering the limited articulation some shots required. 'In the scene where Nell enters the great hall to confront Crain,' noted Hayes, 'these ram statues turn their heads to watch her—that's all they do! To build a computer model of that was a lot of work for what they got out of it; and from a practical standpoint, it didn't seem to make sense. But those kinds of things are not for us to say—maybe that's what they really needed for the movie at that point.'

The main challenge of the staircase griffins—which looked like aged bronze—was creating realistic movement in a figure made of metal. 'At first,' said Blair Clark, 'the griffin was going to transform into a fleshy creature with feathers; but that was decided against, and they requested instead that it be animated as if it were metal. That meant we had to hold back and make the movements tense and slow. It was difficult to retrain ourselves to do that kind of stiff animation, especially since we were just coming off of *Starship Troopers*, where everything had to be fast, fast, fast.'



Visual effects supervisor Scott Farrar reviews a scene in which sculpted figures on a door come to life—one of several last-minute add-ons to the film assigned to Industrial Light & Magic.

A KNB animatronic griffin was also on hand during shooting, giving Jan De Bont more options and alleviating some of the load at Tippett Studio. ‘We obtained fiberglass copies of the griffins from the Tippett art department,” noted Nicotero, ‘and we actually cut out the neck section and put in a more flexible neck. After that we inserted a four-way cable to enable the head to move from side- to-side and up-and-down.”

In the final showdown between Nell and the Crain entity within the great hall, the apparition is more well-defined than in previous incarnations. In addition to the entity itself, the Tippett Studio had to endow the sequence with an interior storm of dust and debris, statues shaking and rolling from side to side, and chairs, tables and settees stamping in rage. ‘The Crain entity sequence was intended as the one time when the audience would really see the Ghost,” explained Craig Hayes. ‘But since they didn’t really want the audience to see too much of the Ghost, we shrouded him in a lot of atmospheric elements and light rays. That meant that this scene had a lot of different layers- dozens of layers for some of the shots- and each of those layers had to be blended throughout. There were also many particle-type effects, so the whole thing was very time-consuming and render-intensive.”

The atmospheric storm surrounding the Crain entity was also computer generated, since little had been done practically on the set to suggest it. Completed at the end of effects production, when time was particularly short, different elements of the storm were distributed to different animators, rather than having one animator take charge of every element of a single shot, as is customary. ‘It is better if one person has control over all the effects elements of a given shot,” noted Eric Leven, ‘but there was so much to do, and so little time to do it, we had to come up with a different system- and it worked very well. Each animator focused on just one of the storm elements. For instance, Tim Teramoto was doing what we called the “pigpen’ pass, which referred to trailing dust and smoke, while Matt Hightower was responsible for the dry-ice pass.” Julie Newdollar’s team added shafts of light coming through the windows, which helped to identify the space the entity occupied in frame as he emerged and disappeared through the dust and other storm elements.

Data-heavy renders were the order of the day. ‘There was a lot of smoke and dust,” said Newdollar, ‘and the deeper the smoke was, the bigger and heavier the render was. These layers of elements would either choke the machine or not render at all, or would take such a long time to render that we couldn’t have finished the show on time. The compositing department had to come up with tricks, rendering layers separately.”

Those compositing “tricks’ not only facilitated the rendering process, they gave the compositors more artistic control over individual elements. Control of when Crain’s visage would be visible in the storm and when it would recede, for example, was squarely in the hands of the compositing team. In a series of shots overseen by Zoe Peck and Bill Eyler, the image of Crain would move away and then toward camera. ‘When he leaned back,” Brennan Doyle related, ‘his face disappeared; and when he leaned forward his face reappeared. The luminances were turned on and off by us to make his face visible or not visible. So, in a sense, we were animating things to help punctuate the high points in the shot. In addition, we were compositing The Many, many layers of elements- little things that aren’t noticeable until you’ve seen the shot a

hundred times. There were bones that would be apparent for just a couple of frames, then dissolve off, or a hand that would become visible for a brief time. All of those layers were animated on and off by us.”

The sequence also presented Doyle and his team a rare opportunity to manufacture practical effects, such as a trailing aura generated in a cloud tank. ‘The stuff peeling directly off Crain was computer generated,” said Doyle, ‘but the stuff floating out in space was photographic. We built a four-by-three-foot tank, which had a small ink chamber inside. The ink chamber had cheesecloth on the front, and the ink was squeezed through that. Making the rig was a lot of fun. We pulled apart some old hard drives and took the magnets out and made some little fans to create interrupter patterns in the water. When we dropped ink in, those little fans would make the ink swirl around. We shot that with a digital camera, and used those elements for shots that were basically lock-offs, without a lot of interior motion inside the frame. For those locked-off shots, the tank elements gave us nice lighting and much better imagery than what we could have realized in the computer.”

When De Bont continued to add more and more Crain entity storm shots, the count grew too high for the Tippett team to reasonably deliver the shots, given the amount of time left in the effects schedule; and so, twenty-nine of them were handed off to visual effects supervisors Scott Farrar and Pat Myers and their crew at Industrial Light & Magic. ‘At the start we were just going to provide dust and storm elements,” said Farrar, ‘which we did with particles. Each of these shots had to be done very quickly.” Toward the end of the schedule, De Bont tweaked the Crain entity sequence so that it included “door people”- cherubic apparitions that emerge from the sculpted figures to confront Crain. Those shots- along with shots that had the door people interacting with the Crain entity- also went to ILM since Tippett Studio was already overburdened with its original effects load. ‘We acquired the shots of the door statues coming alive and moving toward Crain and grabbing him. Since there was so much interaction between the statue figures and Crain, it was easier for us to do the whole shot than to try to integrate our work with Phil’s Crain entity. So we animated some of the Crain shots, too.” To facilitate the process, Tippett Studio provided its computer model of the Crain entity to ILM. The model served as a guide for the ILM crew to rebuild, paint and animate the character in a two-week period.

Despite ILM’s last-minute assist, the burgeoning shot count required herculean efforts from the Tippett Studio for the company to finish its shots and meet its nearly impossible deadline for *The Haunting*. But that kind of heroic effort is becoming the rule rather than the exception, as bottom-line-conscious studios mandate the making of ever bigger pictures on ever tighter schedules- and the trend is taking its toll on effects artisans throughout the industry. ‘This show really burned us out,” Tippett admitted. As if in testament, Tippett- barefoot and unshaven as he reviewed a finals reel- commented, ‘This is the entrance of the house... I can’t remember the name of the house.”

‘Hill House,” someone reminded him. ‘As in “The Haunting of...?”’

‘Oh, yeah,” Tippett said sheepishly. ‘My brain is fried...”

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JACKING INTO THE MATRIX

image

ARTICLE BY Kevin H. Martin

The future is not what it used to be.

Over the last few decades, it has become increasingly popular to bemoan the path of progress— a progress that has fallen short of the glorious visions of sixties-era Popular Science magazines and the like, which predicted a future in which commuters would fly to work using Bell jet packs or teleoperate lunar bulldozers from the comfort of their robot-cleaned homes.

But what if it was not just our vision of the future that had been derailed, but the very reality in which we lived our lives? What if the consensus notion of reality was no more than a group hallucination or a construct? These disturbing ideas inform the backstory— and essence— of The Matrix.

The film depicts the recruitment of computer programmer Thomas “Neo” Anderson (Keanu Reeves) by humans who demonstrate to him that his “reality” is nothing more than an elaborate computer simulation known as The Matrix. An artificial intelligence— A.I. in computer parlance— having defeated mankind in a global war, now maintains the surviving mass of humanity in a docile and unaware state in order to harvest it as a power source. The human rebels with whom Neo joins live outside The Matrix’s artificial reality, far beneath the scorched and pitted ground of future earth, where they are hounded by marauding machine sentinels. Whenever the humans jack into The Matrix’s virtual reality, they are pursued relentlessly by the A.I.’s sentient software— agents capable of possessing the forms of other “real” humans at will— against which the rebels have no



Created by writer-directors Larry and Andy Wachowski, The Matrix is a stylish and original film about a future in which computers have conquered the earth, but have kept mankind unaware and docile through a virtual reality program known as The Matrix. The film’s cyberworld setting is established in its title sequence, in which lines of stylized computer code are displayed cascading down a monitor screen. The title graphics were created by Animal Logic Film, one of four digital effects facilities that contributed to the project.



Manex Visual Effects took on the bulk of the show’s most demanding shots, including a number of spectacular fight sequences in which characters exhibit physics-defying capabilities. Trinity (Carrie-Anne Moss), one of a band of rebels that lives in hiding in the real world, confronts a police

defense. The hopes of these rebels lie with Neo, who may be “the one” – a human capable of transcending all the boundaries defining The Matrix universe, and thus freeing the human race from the tyranny of machines.

officer dispatched by agents of the artificial intelligence behind The Matrix.

Owing some debt to the new wave of science fiction born in the sixties, and even more to a cyberpunk subgenre pioneered by author William Gibson– whose Johnny Mnemonic screenplay became a 1995 movie starring Keanu Reeves– The Matrix emerged a strange hybrid: a venture combining stunning martial arts action with a brainy approach to science fiction.

The film’s two writer-directors, brothers Larry and Andy Wachowski, had brokered their comic book writing talents into careers as successful screenwriters, and had branched into direction with the critically praised *Bound*. The brothers’ visual style– heavily influenced by their comic book background– featured a startling sense for depicting time, favoring the ultra-slow-motion used first by German filmmakers covering Olympic participants in the thirties. This technique, successfully embraced for the slow ballets of death seen in *The Wild Bunch*, had degenerated into a hoary cliché in recent years, but the Wachowski brothers would reinvent the stylization.

The brothers’ vision for *The Matrix* included a fracturing of time that could not be realized through traditional high-speed shooting alone, however. Enter Manex Visual Effects, under the guidance of visual effects supervisor John Gaeta and associate visual effects supervisor Janek Sirrs. Following the fragmentation of Mass.Illusion– an East Coast effects house best known for its work on *Judge Dredd* and *What Dreams May Come*– part of that company’s staff had remained behind to found Innovation Arts, while another faction settled in Northern California as Manex Visual Effects, a division of Manex Entertainment. ‘We hooked up with the Wachowskis in the summer of 1996,” John Gaeta related. ‘They knew our reputation for doing specialized photography– building unusual rigs and bringing eccentric approaches to motion control– and approached us with the idea of doing something unique photographically.”

“Unique’ figured in the brothers’ approach to many aspects of shooting the movie. ‘They incorporated subtle, near-subliminal nuances into the film’s design,” remarked Gaeta, ‘along with bold effects that jump off the screen. They played with shutter speeds to accommodate motion blur for different frame rates. They’d shoot a rehearsal, then have it speed-warped in AfterEffects at a variety of frame rates. They utilized 300-frame-per-second cameras on set for every day of the shoot. All of these techniques and alterations in time created new physiological and psychological moments for the audience.”

Manex was awarded the bulk of the film’s visual effects shots after a fierce bidding war, but the total shot count more than doubled once studio executives at Warner Brothers viewed the exceptional cut footage and, impressed, loosened the purse strings. To accommodate the additional workload, visual effects providers from Australia, where the film was being lensed, were recruited. Dfilm Services labored on more than a third of the film’s effects shots, while Animal Logic Film was tasked with the literally mind-blowing finale, as well as creation of the distinctive computer code defining *The Matrix*. Prosthetic and animatronic makeup effects were handled by in-country vendors: prosthetics by Bob McCarron, and animatronics by Paul Katte and Nick Nicolaou of Make-Up Effects Group Studio. Brian Cox and Steve Courtley shared the

physical effects duties, while additional visual effects came courtesy of Amalgamated Pixels. Finally, Innovation Arts would engineer a custom rig for its former crewmates at Manex, enabling them to achieve a new spin on frozen-time filmmaking.

Conceptualizing the fantastic vistas described in the script would take the Wachowskis back to their comics world roots. Comic book illustrator Geoffrey Darrow produced conceptual art that helped clarify aspects of the brothers' densely complex screenplay when it was first presented to impressed, but somewhat confused potential backers. Together with Spider-Man artist Steve Skroce, Darrow created a storyboard so elaborate that it came to resemble a graphic novel—stylistically appropriate, given the Wachowskis' background. Oftentimes, these conceptals were scanned directly into the digital environment, then tweaked by CG artists, resulting in final images that faithfully translated and dimensionalized Darrow's flat art.

Also involved during the design period were animator Grant Niesner, conceptual artist Steve Burg and matte painter Yerant Douvalian. Gaeta employed five other high-level artists—technical directors in their own right—who joined the visualization team at Fox Studios Australia, where the production was based. "Things were constantly evolving," noted Gaeta, "so having our visualization staff right there within the art department was awesome. Production designer Owen Paterson used CAD to design his sets, and we provided textures to his art department so they could experiment on their CAD mockups to get an idea of the final look. In return, they gave us their CADs so we could do visualization for effects shots involving their sets." The visualizations proved to be a valuable resource during the main-unit shoot. "Every day on the set, I would use AfterEffects to stage-composite new elements, replacing the visualization elements a piece at a time. These stage comps went into the cut until the real shots were ready."

The logos for production company Village Roadshow and distributor Warner Brothers appear at the film's start, but each was altered for effect by Derry Frost, of Amalgamated Pixels, who recolored them with the distinctive green hue of Matrix ectoplasm that would become one of several recurrent, unifying visual motifs in the picture.

A display of computer code fills the screen, registering the film's title. Animal Logic Film, led by visual effects supervisor Lynne Cartwright, was tapped to create this visual. "The Matrix code consisted of a custom alphabet that combined numbers, letters and symbols from various cultures," stated Cartwright. "When you observe real code, it forms definite patterns as it scrolls. Our code included that aspect, while also conveying a futuristic feel. To find the proper vertical flow, we looked at waterfalls for reference, ultimately electing to emulate rain streaming down a window." Proprietary inventions for the shot included the creation of an alphanumeric character generator and specially developed shaders. The cascading code was enhanced during compositing with the film's signature element, a green-tinged phosphorescent effect that indicated the action was occurring within The Matrix universe, not the real one.

The title segues to a telephone trace program, which incorporates a track-in to- and through-numerical characters appearing on a monitor screen, until the camera appears to enter the 3D pseudo-reality of The Matrix. After studying reference video of computer screens, Animal Logic realized a CG surface of the computer monitor with a custom shader that emulated existing

modern-day pixel arrays. 'Like the title code, the trace program utilized a plug-in that automatically ran a random-number system," animator David Dulac noted. 'It also featured a 3D shader, written by programmers Justen Marshall and Chris Bone, that created an enhanced version of the cascading water look of The Matrix code."

The transformation of a numerical character into a dimensional shape suggests entry into another environment. Creating this transition into the digital world required a great deal of design exploration. 'We started with 2D visualizations," stated Cartwright, 'then proceeded to 3D looks and movement tests. For the moment of transition to 3D, we wanted the large numeral filling the screen to push forward through a plastic film-like layer, deforming that flexible surface with this force from a whole other world." Dulac employed Chalice to create the necessary deformation in the numerical character, causing it to bulge from the screen, inflating like a bladder.



Acrobatic fight scenes were enhanced via "bullet-time" effects, in which a subject appears to freeze in midair as the camera continues to move around it. To create the effect of Trinity frozen in time, Carrie-Anne Moss was hung on wires against a greenscreen, then shot performing the desired action with an array of still cameras.



Though the effect had been implemented in commercials and elsewhere, Manex refined the technique for *The Matrix* by separating foreground and background imagery, thereby enabling greater camera fluidity. Digital effects supervisor Rodney Iwashina checks out the bullet-time camera setup on a greenscreen stage.

The dimensionalized character was depth-augmented with a tunnel of light created in Mental Ray and RenderMan. The effect- seen whenever the story transitions from the real world to The Matrix- featured a ghost-trail of gas that was embellished by subtle RGB offsets around each pixel, while additional activity was suggested by changing the position and the intensity of pixels every ten frames. To create greater depth, these pixel grid effects were layered atop one another in compositing.

At the tunnel's end, we arrive in what appears to be the real world, with a group of police officers- directed to a seedy hotel by the telephone trace- bursting in on Trinity (Carrie-Anne Moss), a member of the human rebellion that is aware of The Matrix and opposes the machines. Trinity is forced into action, quickly dispatching the officers in an amazing demonstration of superhuman fighting techniques and acrobatics. The fight was achieved in part by wire-rigged stunt people performing martial arts moves, shot at variable frame and shutter rates. But visual effects also figured prominently, especially when Trinity appears to freeze in midair while the camera trucks 180 degrees around her- the first example of the "bullet-time" effect featured throughout the film.

Similar frozen-time/time-slice effects- utilized most often in commercials to freeze one isolated element of action in the midst of a fluid camera move- had been developed at a number of different facilities by the time The Matrix got underway in 1997; but the approach was still in its relative infancy, having not yet inundated the airwaves or made its debut in feature films. Most of these processes employed an array of still cameras- fired simultaneously- to capture a subject in motion. When these images were joined together to form consecutive film frames, the result would be a time-frozen subject seen from changing perspectives. A high level of image interpolation was also usually involved, to generate in-between frames that extended this frozen moment to the desired duration.

In addition to frozen time, The Manex approach would allow for the creation of "incremental time," simulating the result of a high-speed camera shooting at up to 12,000 frames per second. The process began with the videotaping of a stuntman performing the desired move. 'We digitized the tape and body-tracked it, putting a CG figure over the stuntman,' Gaeta commented. 'From there we could experiment with the movement and the frame rate. The



Previsualization helped The Manex team to determine placement of more than one hundred still cameras, supported on a rig designed and built by Innovation Arts. The cameras, positioned just inches apart, would each capture the subject from a slightly different perspective. Those captured still images would then be interpolated digitally to create a smooth tracking move around the apparently frozen subject.

directors would select the degree of time stylization needed, and we'd show them that speed as a previz option. Then we'd build a camera move- letting them pick the lens- that fit their needs cinematically. Visualization allowed us to calculate positions for each still camera and to determine the exact points at which each would be aimed. This differed from a lot of past frozen-time/time-slice stuff, since all of the cameras in those systems are pointing at the same unvarying point of interest. Our methodology allows for a free-roaming point of interest- just like any regular camera shot. You could start on Neo as the principal object in frame, then pan the camera over to someone else during the track, and still wind up back on Neo at the end of the move.'

To further distinguish the bullet-time sequences from other forms of frozen-time- many of which lacked image clarity- Gaeta decided to shoot with shutter speeds set at 1/1000th-of-a-second exposure times. 'I had been involved with Showscan when I worked for Doug Trumbull," said Gaeta, 'and I liked the idea of getting images of that quality and sharpness, but without having to get into the sixty-frames-per-second projection playback that system used. Using these high shutter speeds on set meant relighting to accommodate the exposure levels, but it got us really crisp images."

In addition to determining the specifics of bullet-time camera moves, the visualization process was used to work out the physical placement of the still-camera array. 'Figuring out how to position the array of cameras properly was one of the first problems needing to be solved," said R&D technical supervisor George Borshukov. 'The visualization move employed virtual cameras that corresponded in dimension to the cameras we'd be using on set."

The on-set placement of cameras- worked out with virtual cameras during the visualization phase- had to represent key positions that could drive frame interpolation for in-betweens. 'Visualization might show a camera move that arced through a path in 3D space, like a piece of string on a crazy curve," said technology supervisor Kim Libreri, 'and we'd have to mock up hundreds of notches along this path to correspond to the number of frames required for the shot's full length. Ideally there would be cameras at all of these positions, but the notches on that string would be too close together for all of the cameras to exist in physical space, since each still camera measured about eight inches long." To ensure that the still cameras would not overlap one another, a Softimage plug-in used collision detection to determine the physical space needed for each camera, based on the visualization.

A CG cube was built for the visualization and placed at the center of frame. This allowed Manex personnel to orient each virtual camera to the subject. The data could then be exported out to stage so the camera positions could be calibrated with respect to the subject. The exporting of visualization data to stage had been pioneered at Mass.Illusion years earlier, with Softimage move data routed to their gantry stage for motion control miniature work- an approach that became a production efficiency tool, shaving weeks off stage time by solving collision problems beforehand.

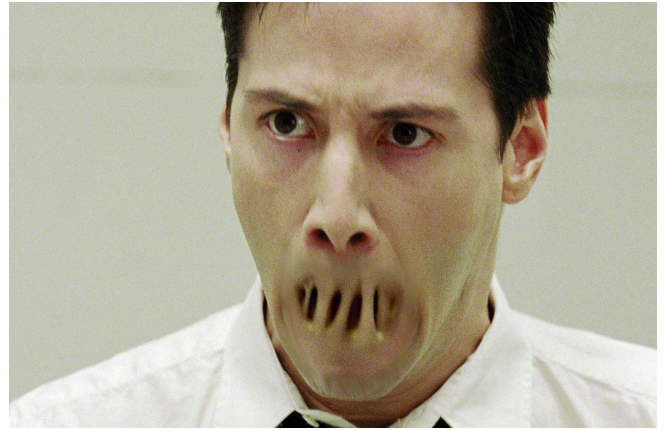
Innovation Arts engineered and built the physical rig to support the array of 122 Canon 35mm still cameras. 'The rig operated like a watchband, in that it could be flexed into nearly any shape," said Gaeta. 'You could do S-curves and go way beyond simple arcs and circles. Then we

mounted a laser on a motion control pan/tilt/roll head that was set up inside a cube– just like the CG cube in the visualization– positioned at these cameras’ area of interest.” The cube, which measured a meter on each side, was covered with diffusion paper, upon which the laser within– articulated via the pan/tilt/roll head and moving in accordance with the data exported from visualization– projected highlights for each point where center rays from the cameras crossed through to intersect the subject, thus allowing the array to be calibrated.

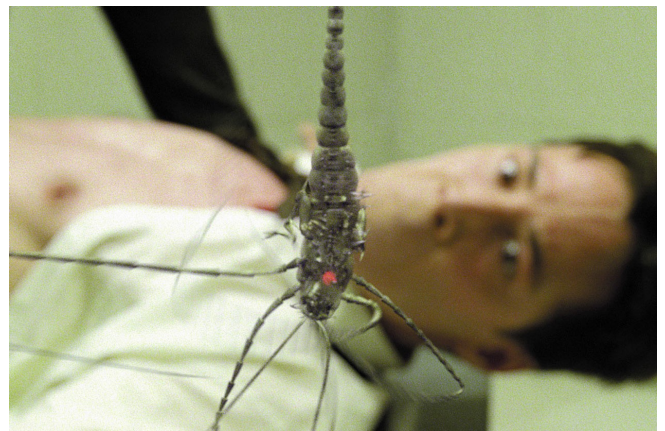
Even after that visualization data had been transferred to the stage, however, a range of temporal options was possible, giving the filmmakers flexibility. ‘We tested different snippets of bullet-time,” commented Gaeta, ‘triggering all 122 cameras at different rates. Then we could alter these timings to accommodate the performers’ actions, if needed, for any of the eight to fifteen takes done on stage. Most of the time we provided the directors at least three different speed options.”

Manex science officer Dan Piponi developed techniques to deal with the formatting of still photographs as they came out of the camera. ‘Not being pin-registered, these still cameras were never meant to be used in this sequential fashion,” Piponi remarked. ‘As a result, images jumped all over the place and exposures differed; and we found the color and grain were off a bit, as well. The cameras just weren’t built to the necessary tolerances. Even a one-percent exposure change was clearly visible when the images were strung together. Some of the setups were a bit off, as well. If you’re working at 3K, a one-pixel shake is visible. We had to bring that pixel into alignment, plus create software needed to color-correct the still images so they could be blended together.” There were distortion issues also. ‘We used a grid that let us see just how far the lenses were diverging from straight lines. With that data in hand, we’d undistort the images with plug-ins for Cineon.”

With a decent flipbook of still camera images now in hand, Manex sought out the aid of Snell & Wilcox, leaders in motion estimation technology, to work out a system for interpolation. ‘Snell &



A computer hacker known as Neo (Keanu Reeves) is contacted by the rebels, then subjected to interrogation by sinister and mysterious agents. When he refuses to help apprehend the rebel band, flesh begins to form over his mouth, making him unable to speak. The illusion originated with prosthetics provided by makeup effects designer Bob McCarron.



Dfilm Services took the effect to its completion through the application of digital techniques. The area around Reeves’ mouth was deformed digitally, then blended with CG skin texture. Dfilm also modeled and animated the squirming CG probe bug that is dropped on Neo during the interrogation scene, though shots of the bug penetrating Neo’s navel were achieved via an animatronic bug tail and a Keanu Reeves torso puppet created by Make-Up Effects Group Studio.

Wilcox had the ability to analyze each pixel and its motion through a frame,” stated Libreri, ‘determining how it corresponds to the next frame. If Keanu’s cape moved in front of his arm, for example, their system could realize what was being occluded and work that aspect out during interpolation. The involvement of Snell & Wilcox solved ninety-five percent of our problems in that area.”

A high-speed movie camera had occupied the first position in the rig for each bullet-time setup, requiring the crew to ease into the still camera setup with a slow camera move. ‘We ramped up speed-wise,” said Borshukov, ‘with an enormous number of interpolated frames during the early part of the move. The acceleration and deceleration at the head and tail of each camera move required careful delineation to keep the motion from appearing too robotic.” Depending on the specific take, there were twenty-five to thirty-seven frames between camera one and camera two that needed interpolation.

Since the bullet-time rig would be visible in shots featuring a 360-degree sweep of the characters, it was employed only for the shooting of the foreground subject- namely, the actors or their stunt doubles- necessitating a different approach for the backgrounds. Shot separately, the backgrounds used a virtual cinematography process that allowed a 360-degree environment to be constructed in the computer from stills taken on set. This approach for generating the backgrounds was based on the Berkeley Tower flyover, a novel image-based rendering technique presented at Siggraph ’97 by George Borshukov and Paul Debevec, a researcher at UC Berkeley. The technique employed twenty stills of that town’s college campus to create a virtual environment through which the camera could travel. ‘Instead of reinventing the background in traditional CG fashion- painting textures, shooting orthographic views of the set, and then proceeding to texture replication- we generated a completely free, high-resolution camera move that would have been impossible to achieve using traditional CG,” Borshukov said, ‘and we did it working from just a handful of stills.”

Laser surveys provided set data, from which simple 3D ref- erence points were recorded. Photogrammetry techniques then allowed the field of view to be registered so that an exact reconstruction of the camera’s position could be achieved. ” It was like standard 3D tracking, but easier,” Borshukov stated, ‘because instead of having to track hundreds of frames, the process involved just twelve to fifteen still images. This variety of images allowed us to construct the environment in 3D.” Custom Mental Ray shaders allowed the images to be projection-mapped onto geometries, via sophisticated algorithms that determined which piece of the computer model would be textured with a given photograph. ‘The algorithms also addressed how each photo needed to be warped to fit the geometry and produce a seamless virtual environment.” Since the stills had been shot with lighting levels that differed from those used on the neighboring live-action images, a relighting of the virtual set was required. ‘We could add in or suck out light from the set to match those adjacent cuts.”

Like the foregrounds, the virtual backgrounds required painstaking adjustments to read as credible motion picture images. Dynamic range, grain and film stock all had to be matched. ‘We used CG techniques to manipulate the photos,” stated Kim Libreri, ‘so when a texture got stretched, the grain in the image stretched, as well. That meant we had to cancel out the grain

before going into virtual background rendering mode. At the end of the process, we plugged the grain back in while matching up the foreground and background.”

After Trinity’s out-of-time display, she makes short work of the police officers and is chased by mysterious suited agents– first up the stairs, and then across rooftops, leaping enormous chasms spanning buildings and crashing through a window to attain safety. For Trinity’s superhuman jumps, Dfilm Services composited greenscreen footage of Carrie-Anne Moss on wires with a rooftop set and separate street scene. “The background became a huge tile,” explained Dfilm digital effects supervisor Jon Thum. “There were two bits of the large studio roof set that we used, plus a plate looking down at cars going by on the ground. The quick camera move following her leap had to stop abruptly, so the take selected had tremendous camera shake that we had to eliminate. We took out the mat she landed on, as well.” Trinity next races to a street telephone, picking up the receiver and vanishing just seconds before an agent-driven vehicle demolishes the phone booth.

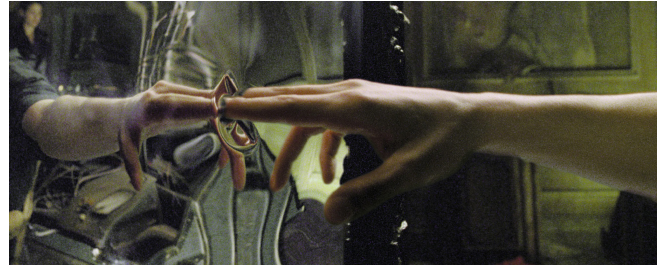
The action shifts to programmer Thomas Anderson– a.k.a. Neo– whose true calling lies with his unique talent for hacking computer systems, an illegal service he provides for a fee. Neo’s perception of reality suggests to him that all is not as it appears in his world; so after receiving a mysteriously prescient message on his computer, he agrees to meet with its sender, who turns out to be Trinity. She warns him of dangers to come, and shortly thereafter, Neo is arrested.

Taken to an interrogation room, Neo rejects a request from Agent Smith (Hugo Weaving) for assistance in the apprehension of a subversive rebel element– the very people he has been seeking out– and the young hacker finds himself unable to speak as skin forms over his mouth, completely sealing it. Bob McCarron’s makeup effects team devised three separate prosthetic mouth elements for the sequence. “We had stand-alone prosthetics for the beginning of the effect, as his lips begin to glue together,” McCarron elaborated, “and for the final seamed-over face. For the in-between stage, we made another mouth appliance, enhanced by Dfilm CGI.”

Two cuts featured the CG mouth work. Computer animation supervisor Sally Goldberg set up the effect, with lead animator Dominic Parker providing refinements. “We wanted to utilize as much of the real mouth as possible,” Parker commented, “so it was mainly a matter of deforming the real flesh as it was drawn down into the mouth cavity, then creating a soft matte between that and some CG skin texture.”

Forcibly restrained, Neo watches helplessly while an agent produces a strange glass-and-metal probe that transforms before his eyes into a writhing cybernetic bug. At first contained within an expanding sac forming at the probe’s end, the bug bursts forth, thrashing to life and penetrating Neo’s navel– an effect created both practically and through Dfilm’s digital manipulations. The bug sac design, in particular, proved to be a source of considerable debate among members of the CG team as it attempted to strike a balance between an organic and a mechanical look. Ultimately, it was decided that the sac would resemble a liquid as it emanated from the end of the metal probe. “Then it would start to solidify somewhat,” elaborated Sally Goldberg, “entering into an egg-white phase, with skin forming on the outside before it burst open to reveal the bug. That was handled procedurally, with the sac grown mathematically.” The procedural aspects of bug animation were done in Houdini, which allowed Dfilm to

accommodate any editorial changes quickly. After the bug's animation cycle had been revised and accepted, the CG model underwent additional modifications; and the Houdini animation from the earlier bug was then attached to the new version of the creature.



Agreeing to join the rebels, and having been administered a pill that will enable him to perceive the real world, Neo's image in a nearby mirror begins to distort. Responding to his touch, the mirror becomes viscous in form, oozing up his hand and enveloping his face and body.



The flowing mirror effect began with a Bob McCarron prosthetic hand covered with a black viscous liquid. Dfilm Services then used the dynamics of the liquid moving on the prosthetic hand as a base upon which to build the effect digitally.

The CG bug's details and textures had to mesh seamlessly with a practical bug tail used on set for shots of its entering Neo's torso. Both bug tail and torso were animatronic puppets built by Make-Up Effects Group Studio. The tail was cast from translucent silicone and built around a small cable-operated mechanism that enabled it to writhe while seeming to burrow down and disappear within the animatronic torso. A casting of Reeves' torso had been provided to MEG, and this underwent supplemental detailing there prior to shooting. 'We resculpted and added skin textures,' company co-founder Paul Katte explained, 'then generated fiberglass negative molds.' Silicone skins were cast, hand painted and airbrushed; and hairs were hand-punched into the finished construct. On the set, two puppeteers operated the bug tail, while nine others controlled the torso mechanisms.



A computer- modeled hand-and-arm was tracked to Keanu Reeves' own in order to link the CG liquid-mirror effect to film elements of the actor. Still photographs taken on the set were tiled together and composited into the shots as reflections in the CG mirror.

Awakening in his apartment, and dismissing his experience with the agents as a nightmare, Neo again meets with Trinity, who offers to take him to the rebel leader. While driving with her to the meeting, Neo is horrified to discover that the bug is actually inside him- a point graphically demonstrated when Trinity uses an electrical device to zap the biomechanism and extract it from his belly. Animal Logic Film employed shaders to generate electricity effects for the extraction device and a variety of other shots, building on hand-drawn animation by designer Jane Milledge, with artist/compositor Kirsty Millar assembling the final in Inferno.

Arriving at a hotel- realized with a thirteen-floor digitally painted set extension embellishing the live-action location- Neo meets the rebel chieftain Morpheus (Laurence Fishburne). After agreeing to join forces with the rebels, Neo has a pill administered, and next sees his visage distort in a cracked mirror. As Trinity and Morpheus observe with interest, Neo heals the cracks in the mirror. John Gaeta shot Keanu Reeves with two cameras so that Dfilm could comp a synced reflection effect onto the mirror area of the frame. 'We had shots of a cracked mirror and a clean mirror,' stated Jon Thum. 'Then the mirror was reshot against greenscreen so we could pick up the cracks, reconstructing the mirror with a displacement map and a clean reflection of Neo. We broke up the image with a reflection map and stuck the cracks over that to match the original cracked mirror. Then we animated the cracks away, gradually sealing up the displacement to bring it back to a clean mirror look.' To give the healing a fluid action, digital compositor Stephen Lunn painstakingly animated all of the cracks separately.

As Neo touches the mirror, the reflection turns dimensional and viscous in form, oozing up his hand and enveloping his face and body. Bob McCarron's team worked on the practical aspect of Neo's hand being covered with the flowing mirror. 'Five days were spent shooting a hand dressed with prosthetics- little webbed fingers and ridges- upon which black goop was poured,'

reported McCarron. "That image formed the liquid dynamics base from which Dfilm launched its effort."

Sally Goldberg and Jon Thum supervised creation of a CG mirror element for the interaction between Neo and the liquid mirror, using stills and tiles to assemble the room as reflections on the flowing surface. "The initial concept for the melting mirror was much more fluid than the final," Dominic Parker stated. "The directors were keen to see coherent reflections of Neo and Morpheus, and that meant going for a single wave with a "thick mercury" look. Since mirror imagery was a big aspect of this show- practically a motif, with many shots requiring reflections to be comped onto mirrored sunglasses- reflected elements were always being cheated and art-directed to specific effect. To link the liquid mirror to Neo's flesh, we created a CG model hand, controlled by inverse kinematics, which David Hodson put through Elastic Reality to lock to the real hand." A morph on the mirror blended all the elements together.

After being engulfed by the flowing mirror, Neo- festooned with hoses that plug into sockets ranging across his body- is next seen bursting from a goo-filled pod set into a tower hundreds of stories tall. This tower is just one of many in a power plant filled with millions of other humans in pods. Neo realizes that this has been his true reality all along, with his life merely a Matrix virtual simulation. For the live-action portion of the sequence, the art department fashioned a partial set holding six pods- suspended fifteen feet above the stage floor to accommodate camera boom moves- and this practical setting became the basis for Manex CG extensions that created the vast totality of the environment.

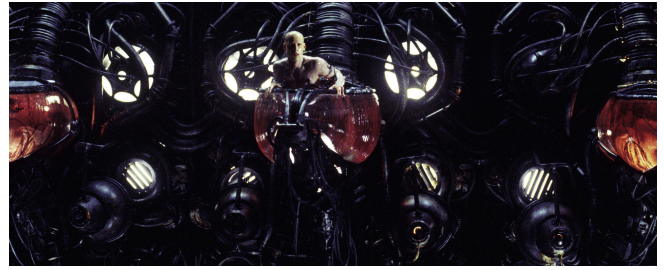
Bob McCarron constructed three minimally articulated dummies for insertion into adjacent pods, and was responsible for the full-body prosthetic worn by Keanu Reeves to suggest his hose-and-socketed body. The prosthetic consisted of several separate parts, and took the eight-person crew- which started at 2 a.m.- six hours to apply, with Reeves sleeping through most of the process. A special bed, capable of tilting to different positions, was built to hold the actor, while a scaffolding rig was set up overhead so his arms and legs could be raised and held without disturbing him. "Halfway through the makeup process, we'd have to rotate him like a chicken rotisserie to make his back up," McCarron noted. "There were large black tubes in the pod that connected to his body, some on his back, supposedly plugging into his arteries and nervous systems through big sockets. The tubes hooked into five-inch-diameter acrylic plates glued all over his body, beneath the prosthetics. For most of the cuts, the tubes were screwed into place, but then they had to snake away. The special effects department made up a reverse high-pressure hose system that plugged into the socket, with the air pressure keeping the hose attached. When air was cut off, the hoses would whip away."

For shots of Neo in the pod before he surfaces and frees himself from the sac, Keanu Reeves was equipped with a breathing apparatus. "The substance used for inside of the pod was a gel, not water," Bob McCarron commented, "so any bubbles in the material would have stayed in there forever. A diving company built a specialized rig that let Keanu breathe without releasing any bubbles. Then we had to go through a number of different gels to find one that wouldn't strip all the color off our prosthetics." Between takes, McCarron's crew pulled Reeves from the pod and placed him in a warming sauna to help the actor shake off the effects of immersion in the bone-chilling gel.

Neo looks out at the power plant, which spans as far as his eye can see. Using stills and plate scans from the set as a basis, Manex technical director Jason Wardle built the power plant's pod-encrusted towers in CG, giving the appearance that the facility stretched to infinity both above and below Neo. Effects animator Al Arthur created huge electrical arcs that crawled up and leapt between the towers like as Jacob's Ladder, while John Nugent composited all of these shots. Many subtle color issues were involved in realizing the environment. 'Generally, a color and lighting guy presents the compositor with a pretty much finished element that can be plugged right into the scene,' observed Kim Libreri. 'But for a lot of these shots, since our compositors were used to dealing with detail and lighting issues in a physical piece of photography, we decided to give them more control over the lighting. Instead of rendering just one pass, there was a multipass setup allowing control over how individual lights contributed to the final composite. Some shots had twenty light layers- ambient passes, speculars- all of which fit into Dan Piponi's new pipeline.'

Piponi's contributions also extended the dynamic range of rendered CG. 'Car headlights at night are light sources thousands of times brighter than the objects around them,' Piponi said, 'and we had the same situation within the power plant. Accurately representing that luminous segment of the dynamic range required a large part of the existing Cineon system to be replaced with plug-ins- color-grading and blurring nodes- which enabled us to get true highlights on the glistening towers in the power plant.'

While still trying to take in the view from his pod, Neo is confronted by a DocBot- a robotic physician that roams the plant, servicing and evaluating its human charges. A mechanical arm flashes out from the front of the DocBot, grabbing Neo by the neck for a quick medical evaluation. A full-size robotic arm was built and featured in



Neo's real-world existence is revealed when he bursts from a goo-filled pod- one of millions within a plant where humans are maintained and exploited as a power source. Six practical pods were built and incorporated into a stage set for the live-action portion of the sequence.



Wide views of the plant were realized with digital set extensions executed by Manex Visual Effects.



For a closeup of the DocBot- a robotic physician- grabbing Neo by the neck for a medical evaluation, a mechanical arm was used in conjunction with a Neo head-and-neck puppet

closeup views of a McCarron prosthetic representing the interface socket at the back of Neo's head- the main connection for jacking into The Matrix.

The full DocBot was computer-modeled very late in production by Grant Niesner, whose design was influenced by spiders and a dragonfly. Niesner modeled and textured the CG DocBot utilizing Alias, Maya, Amazon Paint and Photoshop, while Dan Klem built the DocBot gripper arm, working from the physical model. Jo Littlejohn also played a key role by rigging up all of the DocBot arms containing syringes, blades and the like. 'We modeled it from the elbow to the shoulder,' said Niesner, 'with neat linkages on the arms, plus dangling tubes and exposed architecture. We had pistons, plus parts that behaved like actual tissue. We added round nodules, external tendons and pistons on the legs, plus many miniature medical arms around the face. The reflective front surface is supposed to be like an eye extending out towards him.' For a shot of Neo seeing his own reflection in the DocBot carapace eye, Jamie Pilgrim wrapped a plate of Keanu Reeves struggling with the practical DocBot arm into an environment cube, cheating the actor's reflection to enlarge and center him.

built by Bob McCarron. Full views of the DocBot were achieved via a Manex computer model. Neo is brought aboard the rebel hovership Nebuchadnezzar, where electric stimulation is used to tone his atrophied muscles. A full-body, needle-laden prosthetic was created by the McCarron team and applied to Reeves in a seven-hour makeup session.



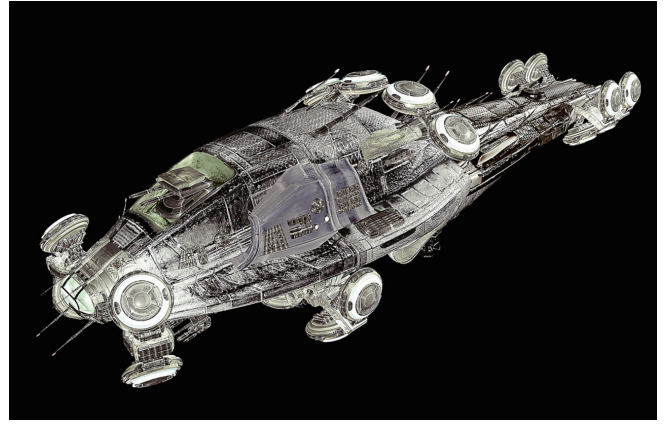
The Nebuchadnezzar maneuvers within sewer tunnels beneath the scorched and war-torn earth. Both the hovership- with electrical animation effects to suggest antigravity technology- and the surrounding tunnel were computer generated.

After the DocBot pulls his connections, Neo finds himself flushed from the pod and plunged into a sewer. Morpheus, having determined his position, is able to retrieve Neo and hoist him aboard the hovership Nebuchadnezzar, which cruises in ancient sewer tunnels beneath the earth's surface. Neo convalesces for months in the ship's infirmary, laid out on an operating table, with countless needles protruding from his skin. 'For this acupuncture sequence,'" said Bob McCarron, 'the directors wanted a thousand ten-inch needles inserted into Keanu's full-body prosthetic. At that length, the needles did not want to stand up- they just flopped over. So we went with small anchor plates beneath the prosthetic. After welding the needles onto these plates, we poked the needles up through the prosthetic from within. Then the whole appliance could be applied to Keanu. It was his worst day on the film- a seven-hour makeup, made worse by the knowledge that he wouldn't be able to walk, sit up or move for hours. We slid him off the makeup board and onto a medical gurney, put him in the back of the car, then took him to the stage and slid him onto the operating table for filming.' Three additional body sculptures were required for follow-up shots of Neo's progressive physical recovery over the span of months.

Once recovered, Neo is now open to learning the realities of The Matrix and life outside of it.

Accompanied by Morpheus, he jacks into a virtual environment called the Construct, a white-limbo space used by the rebels for speed-learning and for loading tools that can be used when they enter The Matrix. Here, the truth about the world- in the form of a history lesson from Morpheus- is revealed to Neo, who learns of a devastating war that occurred between man and machine more than a century earlier, and how the human race became enslaved.

To illustrate the devastation wrought in the war, Morpheus reveals the pitted, now-frozen surface of the earth and the remains of a once great city. The destroyed city was first visualized by Nico Grey of Manex while production was underway in Australia, then executed as a digital matte painting by Charles Darby of Digital Firepower. 'I spent a day at Manex reworking the city view,'" Darby recalled. 'While the skyscrapers needed to relate to architecture we know from this century, they also had to seem a bit futuristic. Since I'd worked on The Fifth Element, we went with a look in that vein, but thinking of that city first destroyed and then revisited two centuries later.' After returning to his own facility with the revised city concept, Darby built the



Artists at Manex Visual Effects built and animated the digital Nebuchadnezzar model.



Also computer generated were robotic sentries- called sentinels- which hunt the rebel hovership within the underground sewer system. Design elements suggesting that these sentinels were a combination of organism and machine were reinforced through their animation, which demonstrated that the prowling entities had the ability to propel themselves in a squidlike fashion as well as utilize their tentacles with robotic precision.

cityscape up by first painting it as an undamaged environment. 'It was easier from my standpoint, since I knew how the structures were built and could use that knowledge to create a logical pattern to the devastation I would be carving into them. If the filmmakers decided they wanted more damage in certain areas and less in others, I could revert to a previous version. It was quite liberating to be able to build the city and then destroy it.'

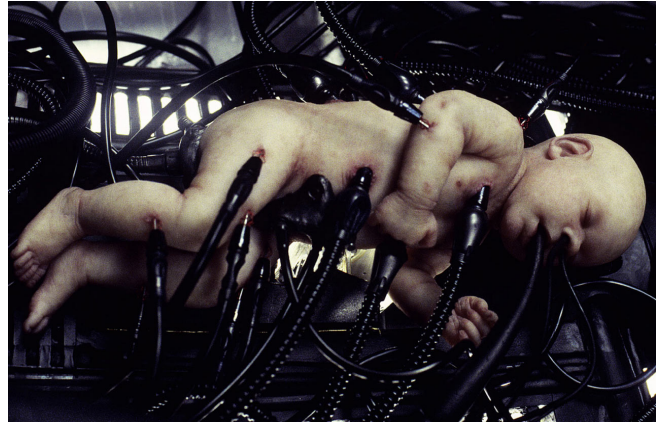
Darby utilized Photoshop for 2D and Satori for 3D, which allowed the artist to work details in through separate layers. Also added to the paintings were interactive light passes relating to turbulent skies. Technical supervisor John Volny composited the city painting with time-lapse cloud elements, working with compositor Dan Rosen to create a seamless transition to a live crane shot booming down to a closeup of Laurence Fishburne. 'The camera dives off the painting down to Neo and Morpheus in their easy chairs at the bottom of this dried out lake bed,' recalled Rosen. 'There was a huge series of textures linking the matte painting with the live-action. Originally the entire environment was going to be a painting, but after determining that it would have to be 16,000 pixels wide, the multiple technique approach arose.'

'A complete CG terrain was built to marry the matte painting with that crane element,' elaborated digital effects supervisor Rodney Iwashina. 'From the sea bed to the city, it was all little pieces of scenery separated out, with each one being applied to the camera move, essentially gluing the image back together.' The CG environment was built, texture-painted and animated by John Volny using Softimage and Photoshop, while software developer Jeremy Yarbrow generated volumetric atmospherics for wispy additions to the cloud elements.

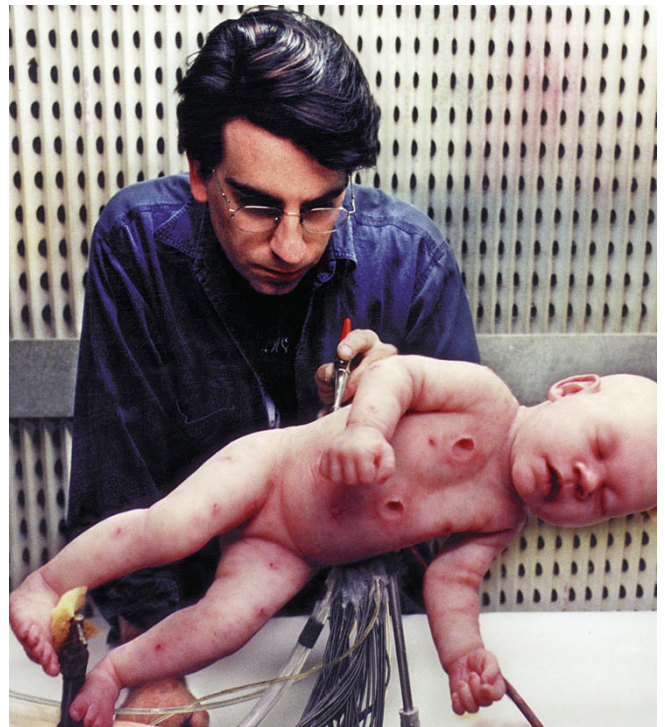
Morpheus next explains to Neo that after the machines defeated humankind, man's usefulness became limited to serving as a power source, with vast fields containing countless fetuses being harvested by machines. His recitation is augmented by a dramatic shot starting on the eye of a fetus and pulling back to reveal the robot tenders of a fetus field. The lengthy pullback shot was entirely computer generated by Manex. 'Work began on that shot the day we were awarded this show,' John Gaeta acknowledged. 'Pulling all of the various elements together to make it work took us almost a year and a half. There was a ton of design work, beginning with how we would get the closeup fetus to look realistic while incorporating obviously unnatural elements, such as the brain jack at the back of the neck. When they're plump, the babies are picked by huge arms coming off these harvester units. The babies get pulled into a harvester's bin before being brought to the power plant, where each is inserted into a pod- like the one we saw Neo emerge from- and lives out its life there.'

For the pullback from the fetus eye, Grant Niesner first modeled an entire skeletal system for the fetus, complete with internal organs. 'We needed the internals so there'd be detail if the brothers wanted to go more transparent with the skin,' stated Niesner. 'The interior of the pod wound up obscuring some of that, which was okay because showing too much would have made it look too clean.' When completed, the pods consisted of four layers: a clear membrane, the fleshy tissue of the baby, a layer of grimy bits and a mucus layer. Technical director Rudy Poat developed a series of shaders- surface, displacement and light- that could be linked together and used globally, with options like dripping mucus that could be created as noise functions. Lead shader writer Steve Demers augmented Poat's work by adding light absorption and iridescence features, as well as particulates suspended in fluids, while the fetus was animated

in Maya by Niesner. Brett Hartshorn painted skin and vein texture maps using Amazon Paint and Photoshop.



In a history lesson related by the rebel leader Morpheus (Laurence Fishburne), Neo learns of vast fields of human fetuses being harvested by machines. The lesson ends with the image of a newborn infant being installed in a pod festooned with hoses. Artists at Make-Up Effects Group studied videotape reference of a real newborn to create an animatronic baby for the shot.



Company co-founder Paul Katte paints the realistically fleshy silicone skin of the pseudo-baby.

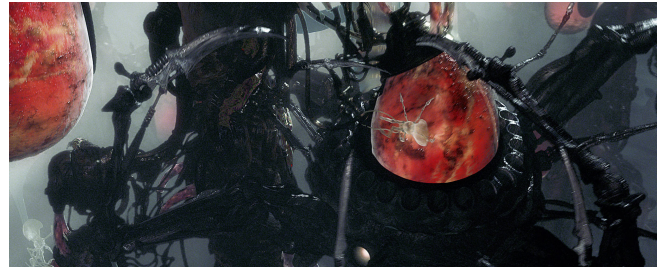
Also in this pullback shot are numerous creatures, ranging from tiny organic parasites crawling over the pods to giant harvester machines roaming across the fetus fields. “The idea was to find some area of creaturedom that hadn’t already been done to death,” John Gaeta commented. “We decided that undersea lifeforms were a good bet—creatures that were light-absorbing rather than light-reflecting; things like jellyfish, certain octopus and sea anemones, with translucent skins through which membranes and muscle tissues were visible. We looked at a lot of great undersea reference while designing the pods and creatures, studying the colors and the patterns in coral reef environments. Creating the variations on these took awhile— the palette of options left on the SGI floor was amazing. There were techno-millipedes with LED-like eyes, flying creatures called bio-loons swarming around the harvester bins like flies over a garbage can, and droid-like bees servicing various stalks.”

Jamie Pilgrim wrote a flocking plug-in within Maya that was capable of handling a large quantity and variety of creatures. “Many of the aerial creatures designed for the shot were ultimately discarded,” said Pilgrim, “but the system was used for the parasites crawling on the fetus pods. The system could detect the surface those parasites walked upon; and my code let them feed info about the footsteps back into the surface, dimpling the fleshy surface of the pods and causing the light inside the pods to focus at that point with a naturalistic lensing effect.” The millipedes slithering along each fetus stalk were also designed, built and animated by Pilgrim. Their movement used an offshoot of the same flocking system, allowing users to draw a path on the stalk for a millipede to follow.

Grant Niesner designed the harvester’s claws, which, along with the harvester bin and body, were modeled by Sean White. “The foreground claws and background harvesters were all animated by hand to give more control than we’d have had with a procedural approach,” remarked Niesner, “but it meant a lot of tedious work, since each harvester had six tentacles ending in claws with four large arms and eight small arms, all of which had to be animated in the closeup pickers.”

Background fetus stalks required some limited perspective changes, which meant going beyond a straightforward 2D approach. “The background stalks were flat planes, upon which we could attach appropriate views,” Steve Demers remarked, “depending on the camera’s orientation.” To produce the desired swamp-gas look for the fetus field, Demers developed a specific multi-fractal noise function, producing volumetric atmospherics that could be rendered with a custom RenderMan volume shader.

The history program concludes as the CG pullback dissolves to a practical on-set view revealing a newborn infant freshly installed within a pod, already festooned with hoses. Make-Up Effects



Computer generated shots of the machines harvesting the fetus fields were created at Manex Visual Effects. The harvesters were designed and built with four large arms, eight smaller ones and a fleshy orifice, each of which had to be animated separately by hand. The organic look of the fetus pods— which included an outer membrane, internal mucus layer and the fetal body tissue— was created largely through custom shaders.

Group Studio fashioned the animatronic creation after studying extensive video and photographic reference of a real newborn. Detailed textures and forms were replicated in clay by Paul Katte, who added airbrushed detail to the silicone skin. The sculpture was broken into sections and molded to allow animatronics designer Trevor Tighe to install self-contained mechanisms before the start of the silicone casting process. "The intricate components were machined out of aluminum and brass," explained MEG co-founder Nick Nicolaou, "with ten puppeteers operating fifty-five cables that exited through the baby's underside to bring the baby to life."

Neo undergoes a mental and physical training regimen while aboard the Nebuchadnezzar, receiving downloads that allow him to learn a variety of skills instantly. Neo's new talents are demonstrated during a martial arts session with Morpheus, his fierce blows falling with blurring velocity in a kind of cinematic superspeed. "That was a cascade-style printing that we called "recursion,"" John Gaeta explained. "We had shot those fights at 96 frames per second, so there were plenty of images to play with. We added or subtracted frames to create a choreography of blows that was graphic, laying several images over one another to create a fanning-out effect."

With the subsequent loading of a jump program, Morpheus and Neo find themselves plunging at terminal speeds toward a cityscape, soon touching down on a skyscraper's rooftop. The shot was accomplished with a combination of location work and matte painting. "That was visualized in 3D as a powers-of-ten style descent toward the city," related Gaeta. "At a certain point, a building would start growing up toward them as the digital file loaded in. We calculated the rate of travel, then shot an aerial plate on location, descending toward a rooftop while zooming out-like a Hitchcock Vertigo shot. In post, we did a huge tiling effect for the surrounding cityscape to create the impression of even greater height. That was necessary because the live-action plate was taken only three thousand feet up and gave us only enough image for the middle sixth of the frame." The camera pulls back abruptly as the pair is deposited on the rooftop- actually a gigantic digital matte painting created by Dan Rosen, based on reference photography shot on the production roof set.

To demonstrate that there are no limits in The Matrix universe, Morpheus makes an incredible leap to another building in a sequence accomplished by Dfilm. "For the jump," related Jon Thum, "we started with a close view of Fishburne jumping against greenscreen, then swapped to a stuntman on a wire for the landing on the other side. When the actor jumped, we let him go out of frame at the top, then tilted up to pick up the stuntman coming down."

Neo tries to duplicate the leap, but instead falls to the street below, ending the training session. The elaborate camera move following Neo through his fall featured a background plate that was shot by production and heavily manipulated in 3D to make it match up with the live-action Keanu Reeves element through the change of perspective during the jump. "We had a huge set with Keanu on a wire to allow for a 270-degree camera move," explained Thum. "Even so, the move wound up being



When Morpheus is captured by enemy agents, Neo and Trinity order up guns in the virtual training environment of the Construct. For shots of gun racks rolling into view, production first shot practical racks on stage. When it was later

reworked to really sell the idea of falling, beyond what could be achieved on wires. Then we tiled together some sky and buildings using big Vistavision plates.” For Neo’s impact with the street and his subsequent bounce, a rubber-like texture was mapped onto the impact area. Dominic Parker swapped between photography of a stuntman’s fall and Reeves for the ground impacts.

Neo and Morpheus next appear to walk on a crowded city street. Passing a fountain, Neo turns to find Agent Smith pointing a gun at him. Morpheus calls out, causing the entire environment—the agent and all the surrounding people—to slow and then freeze, revealing that this cityscape is yet another synthetic product of the rebels’ training program. Three layers of imagery were composited in Cineon to create the effect. The location background was shot both at sound speed and high speed; and when combined, these created the initial slowing effect on the fountain’s spray and on the movement of background extras. A high number of frames were then interpolated to extend the slowing action and create the frozen-time moment. Foreground extras, who were frozen along with the background elements, were filmed against greenscreen, as were the moving principal performers in the midground.

Back in the real world, Morpheus’ hovership comes under attack from menacing robotic sentries called sentinels, causing the Nebuchadnezzar to duck into a different sewer tunnel and play a game of silent running to avoid detection. For the digital sewer tunnels, Gaeta’s team studied reference of shipwrecks to capture the look of corrosion and very soft diffuse lighting. Technical supervisor Ivo Kos used RenderMan shaders to come up with corroded dirty metallic surfaces, Enrique Vila modeled the tunnel system, and Mike McNeill supervised both the tunnel and Nebuchadnezzar development. Rob Nunn, who started in the on-location Manex visualization department, went on to build the digital hovership model.

Steve Burg conceptualized the robotic sentinels to suggest a near-organic quality, even while they glistened with metallic hues. “The sentinels relate to the stomach bug through subtle nuances in movement that suggested the systematic intelligence guiding all of the machines,” stated Gaeta. “The motion imparted to each creature’s tentacles is quite similar—while it is hard to see on the bug because it moves so fast, the strands on the sentinel show sinusoidal crisscrossings that repeat in a cyclic, symmetrical pattern, to which noise was added to break the look up a bit.”

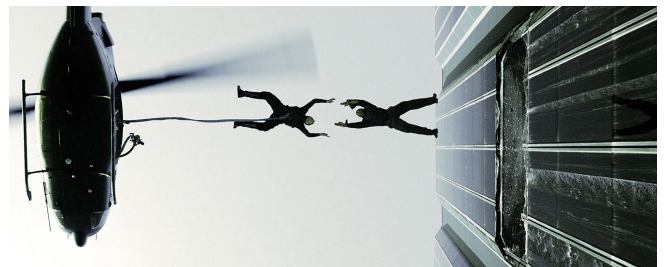
Ivo Kos modeled and textured the sentinel body, while Grant Niesner fashioned its various appendages. The sentinels were animated to swim through the underground environment, with procedural approaches in Maya used to create tentacle articulations to augment the spline-based animation. “To get some scary snapping motions for the tentacles,” recalled animation supervisor Matt Farrell, “we played with different shutters on the motion blur, exaggerating for effect. We weren’t limited by a too-conservative approach on this show. In fact, the directors and supervisors wanted even more dynamic moves than we came up with on our own!”

When the time came to create the scene digitally, stills of the physical racks were applied to 3D cubes, which were subsequently animated to roll into frame and used in a similar fashion to the real-life footage. The high-speed effect, the actor playing the part was filmed in front of a greenscreen, his feet planted on the floor as he performed evasive maneuvers. His static legs were then digitally cut out and used as a base upon which overlapping torso shots were layered.

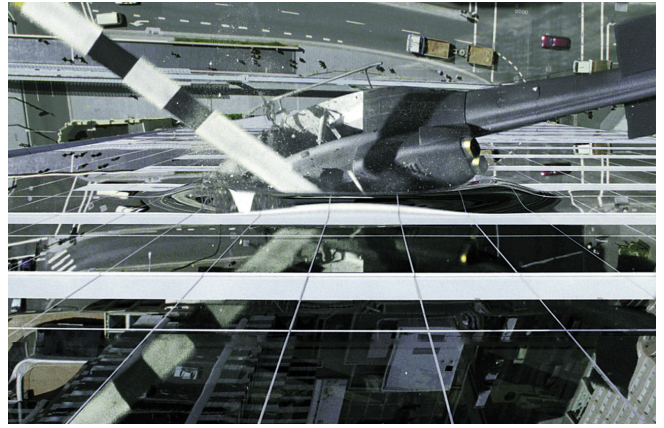
After evading detection by the sentinels, Morpheus and Neo, accompanied by most of the rebel crew members, venture out into The Matrix for a supposedly clandestine meeting. But the rebels come under attack by massed forces intent upon their eradication. Tipped off by a moment of *déjà vu*– the disturbing yet universal psychological phenomena ingeniously explained in the context of the film as a glitch in The Matrix– Neo and his compatriots attempt a hasty escape, but find themselves cut off by A.I. agents. Morpheus is captured and one of his crew is killed, while back aboard ship, turncoat team member Cypher (Joe Pantoliano) slays three of his Nebuchadnezzar comrades and wounds another. Cypher’s weapon of choice– ultimately turned on him by the wounded survivor– is a lightning gun that inflicts massive body-charring wounds. After tracking the movement of the prop gun used on set, a 3D model of it was built at Animal Logic and a beam effect devised. “The directors wanted the blast from that gun to be very big and powerful,” Lynne Cartwright commented, ‘so we shot electricity reference footage at science museums, then assigned a programmer to write the Softimage plug-in and Mental Ray shader for the principal animation bolt, which was tracked to the prop gun movement and composited.” Hand-drawn, hairline-fine arcs coming off the main bolt were added, as were heat haze and moving interactive shadows.

Neo, determined to rescue Morpheus from an agent stronghold, is accompanied by Trinity on the seemingly impossible mission. Back in the all-white Construct, Neo orders up guns– and dozens of weapons racks roll out into view. When a camera move past practical racks produced less than spectacular results, a CG view was created from still photographs. ‘After taking stills of the physical racks,” Dan Rosen explained, ‘I cut them up into pieces and 3D-animated a scene with elongated cubes representing the physical gun racks. We’d put the front of the rack on one part of the cube, then cut out the side and attach the side of the rack to that part of the cube. The little crevices and tiny details were all there from the original photo, so that genuine detail worked like a very good texture map.”

With an expanded perception of his surroundings, Neo, aided by Trinity, is able to cause considerable havoc inside the building in which Morpheus is being held, dispatching guards with gunfire or in hand-to-hand combat, and decimating the building’s lobby with an explosive charge. ‘For the lobby explosion, we used a black-body miniature that was shot at 300 frames per second,” Gaeta explained. “The detail came from a virtual lobby background that we built, working off measurements and pictures of the real set. We had a detailed quarter-scale mockup of the lobby on hand, but the virtual background technique was preferable.”



In the course of the rescue, Morpheus launches himself toward a hovering helicopter, while a tethered Neo leaps out of the craft to catch hold of his leader’s hand.



Hit by agent gunfire, the helicopter crashes into the building. The film's physical effects unit orchestrated the crash of a quarter-scaled helicopter into a like-scaled glass building, as well as the attendant miniature pyro.

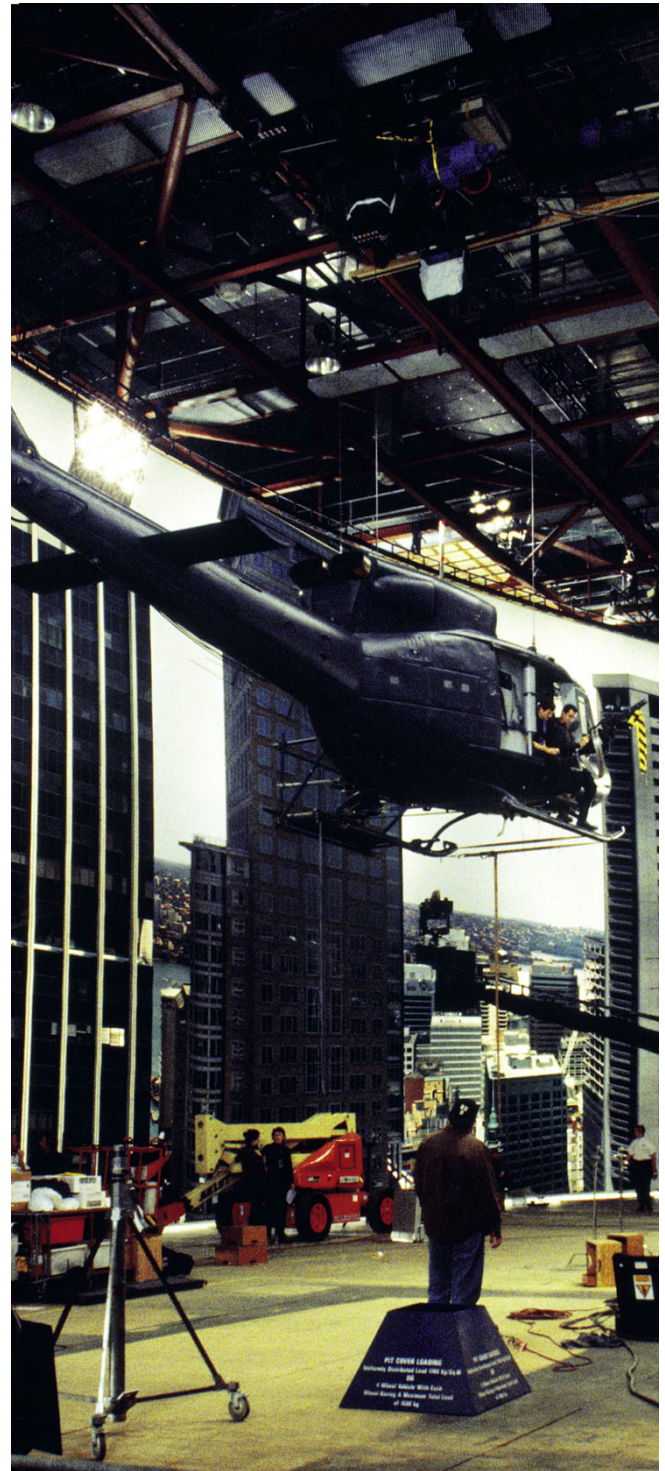


Trinity swings free of the blast as the helicopter explodes upon impact. Dfilm composited greenscreen footage of the actress and pyrotechnic miniature elements with background imagery filmed on location.

The blast sets off sprinklers throughout the building, and the agents within go on the offensive. After a battle on the roof with armed forces, Neo is confronted by a Matrix agent. The computer specter is able to easily duck Neo's gunfire, moving in a dazzling blur of speed, before returning it with some of his own. "The agent seems to turn into six different guys because his head and torso are moving so fast," Dan Rosen commented. 'Creating the agent in "bouquet' form, as John Gaeta described it, was difficult. John and the directors settled on the idea of a recursive effect. The actor playing the agent was shot against greenscreen, keeping his feet planted on the ground as he performed a lot of duck-down and duck-to-the-side actions. I was able to cut out his legs and establish them as static in frame, using that element as a "tree trunk' base that the moving agent torsos could attach to. I would repeat each ducking move, but set it one frame off to create a soft transparent ripple effect that trailed his form. To really speed the agent up, I also step-printed the first part of each move he made."

Without even realizing what he is doing or just how fast he is doing it, Neo dodges the incoming bullets- in another bullet-time moment- before Trinity dispatches the agent with a point-blank round. Dan Rosen's slow-motion bullets were based on the idea of a refractive glass object moving through space and tearing into the fabric of The Matrix. "The bullets started out as a 3D project," Rosen recalled, 'but later I decided to scan the hero bullets provided by production, then map those images onto bullet geometry. This approach was fast and let us move on to attaining the correct level of reflectivity and ensuring the highlights were all there."

Utilizing the Maya renderer and deformation of background 3D geometry to produce a heavily refractive component, Rosen created bullet wakes that featured a heat-haze look. 'A lot of the



Much of the sequence was shot on stage with a full-size helicopter mockup, suspended against an enormous translight of the city. A high-rise building set filled the remainder of the stage and was rigged with shattering windows as well as sprinkler gags. Dfilm Services would later provide additional water, plus digital rotors for the helicopter and hundreds of spent bullet casings to augment those expended on set.

refraction and reflection effects were done in 2D,” Rosen said. ‘We would warp a section of the background with a filter. Then we wanted colored rings in the outer fringe of the bullet wake– an effect that bled and blended into the warp. That was a one-pass operation handled by technical director Gil Barron. The rings then went back on top of the wake to produce a final that was very close to the look everyone thought was so cool in the original storyboards.’ Unfortunately, for frames in which the camera was passing through the back side of a bullet wake, the computer had difficulty rendering the colored rings and maps. ‘The system couldn’t decide whether the wake should be there or not– with a computer, something is either there or it isn’t. We kept getting render errors and strange artifacts when these rings hit the camera– sometimes the image would turn upside down. Ultimately we were able to program a dissolve to glide over the pass-through moment.’”

Since the bullet-time portion of the sequence was filmed on a greenscreen stage, a number of other rooftop objects were re-created in CG for the sweeping virtual camera move, including volume-rendered steam clouds. Lead bullet-time technical director Gerard Benjamin Pierre, together with technical supervisors George Borshukov and Daniel Sunwoo, also re-created physical rooftop elements such as the helicopter, an adjacent reflective building and an assortment of dead bodies in CG, all of which were composited by Tom Proctor.

Trinity takes to the controls of the copter and orbits down to the upper-story floor where Morpheus is being held. Neo, manning the helicopter’s offensive battery, shoots down the three agents holding their commander. The on-stage aircraft assault– featuring a full-sized helicopter mockup and an enormous translight of the surrounding city, along with the multi-office building set– required split-second timing on the part of the floor effects crew to synchronize Neo’s minigun with the building’s windows being shattered. Dfilm supplied water elements cascading down the building’s sides to tie in with the sprinkler activity on its interior.

Up-angles on the copter attack featured hundreds of spent bullet casings– rendered as CG elements– falling toward camera. “ While real bullets were filmed and looked beautiful,” said Jon Thum, ‘they never fell correctly, often hitting the camera. CG bullets could fall right through camera– so that’s what we went with.’”



After Morpheus and Trinity have been spirited away to safety, Neo squares off against Agent Smith (Hugo Weaving), confronting him in a subway.



The battle– which begins with blazing guns and progresses into an extended hand-to-hand combat sequence– was enhanced through the use of wire-rigged acrobatics and bullet-time effects, shot on a stage with the custom still-camera rig covered in green. The subway setting was assembled from an array of still photos projection-mapped onto 3D geometries. Prior to the compositing of background and greenscreen elements, virtual lighting was employed to match the look of the lighting scheme used for the live-action.

Almost immediately after being gunned down by Neo, the agents reappear elsewhere on the same water-soaked floor of the building, taking over the bodies of policemen. The agents' physical possession of virtual humans involved both 3D and 2D morphs, produced by Animal Logic. 'We started with one face pulling out of the other- a traditional morph approach- but it clearly wasn't energetic enough,' said Lynne Cartwright. 'But those morphs became the basis for a 3D effect. All the actors had been plaster-cast, so animator Ben Gunsberger used the molds to create CG heads that could be manipulated in 3D and warped in 2D using Elastic Reality. The morph elements were cut up and reassembled to look like the new face was jerking its way into position, pulling outward and sputtering in an aggressive, painful-looking percussive effect that featured a lot of staccato action and some repeated frames.' In *Inferno*, another image warper wielded by Kirsty Millar was employed to spot-retouch the final image.

Morpheus breaks his shackles and runs toward the hovering helicopter, but agent gunfire strikes the rebel leader's foot, a moment captured with a bullet-time track-in- a camera move not easily accommodated by the rig, since each camera in the setup obscured the one behind it, blocking off a sizable part of the subject. 'To sidestep the problem, we put a bit of an arc into the dolly move,' said Kim Libreri, 'so that the next camera ahead would be over to one side of frame, allowing us to capture a good chunk of clean image.'

The second-unit shot was done at the end of the last day on set, and the rush to wrap created difficulties, with bullet-time passes being shot that included crew members stripping down the set in the background. So much of the image required replacement that The Manex team- Rob Nunn, J.D. Cowles and Gerard Benjamin Pierre- wound up creating most of the background digitally, matching it to set pieces and the translight. 'Except for Morpheus, everything was synthetic,' stated Pierre. 'We replaced most of the frame- including the office wall and the translight- and made the copter CG, as well.'

Morpheus launches himself into space toward the helicopter, and a tethered Neo leaps out of the craft to catch hold of his hand. Trinity pilots the copter away, but bullets rip the fuselage and the flight grows perilous. Neo deposits Morpheus on a nearby rooftop and then pulls Trinity to safety as she bails from the helicopter just prior to its exploding against an adjacent building. 'We had visualized the whole flight,' said John Gaeta, 'so during the aerial location shoot, the stuntmen hanging on could be directed to twist according to the animatic. Then, by blowing up the previz, we could get in close to the faces and see how Keanu and Laurence had to be oriented for their greenscreen closeups.'

Dfilm added rotor elements for the mockup copter, employing a combination of real rotor footage and custom CG creations. 'Most of the copter sequence went into digital,' recalled Jon Thum, 'with close to thirty composites. A large number of shots required color-grading of the skies to change them from blue to white. This meant changing the color on the various buildings to correspond with the whiter skies- but fortunately that effect was easily keyed.'

Taking their timings from The Manex visualizations, Steve Courtley and his physical effects team handled the miniature pyro for the quarter-scale helicopter's crash into a like-scaled glass construct standing in for the location building. Dfilm then assembled the elements, comping the explosion with various live-action plates. 'The glass miniature building was set up to reflect a

greenscreen placed opposite it,” said Thum. ‘But since it was shot outdoors, the lighting on the screen was not ideal and there were shadows falling across it. After the shot was completed, the directors decided they wanted a wider view, so we had to extend the frame beyond the greenscreen at the edges. Pulling glass and bits of dust off the non-greenscreen background was tough.”

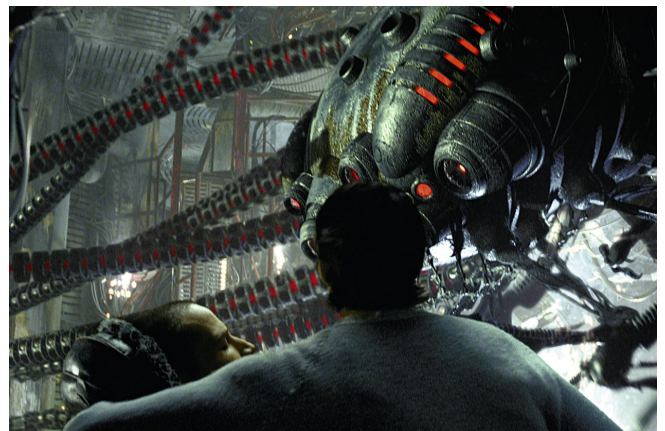
Dfilm also created a lacerating impact ripple that comes toward camera as the copter crashes, using scanned-in city images– a wraparound panorama shot by John Gaeta from atop the crash building– as a reflection element mapped onto the building’s deforming geometry. ‘We produced the 3D ripple using Houdini,” explained Sally Goldberg. ‘We couldn’t get the whole environment mapped, so we did a mathematical emulation of the ripple distortion to extend the effect.” Digital composite supervisors Tim Crosbie and Mark Nettleton handled all the keying of elements.

The rebels enter a subway to dial up an exit at a phone booth, with Morpheus teleporting out of The Matrix and back to the real world. Although the characters had ducked in and out of the machine reality throughout the picture, this was the only occasion in which the event was depicted on camera, with animated shoots emerging from the phone’s receiver and covering Morpheus, who fades out. ‘The idea we began with was a deafening fax sound from the phone that triggered teleportation,” commented Gaeta. ‘The visual pattern emitted from the phone receiver moved with a capillary action, like watercolors spreading over rice paper, so Morpheus’ body was overtaken quickly by this fractal-like pattern, which slowed as it reached the edges of his body.”

Al Arthur developed a branching algorithm to drive the effect, which was accomplished in Maya. ‘Enrique Vila modeled a 3D Morpheus with a single continuous NURBS surface,” stated Arthur. ‘then tracked that over the live-action figure. My algorithm utilized coordinates from his model as 2D move-markers, sending shoots out on paths along the surface that branched rapidly, expanding to cover the whole body. Each frame was calculated iteratively to allow this rapid growth.” To accomplish the necessary integration, Dan Rosen cut displacement swathes through the live-action Morpheus, replacing these sections with the rendered effects element.



Pursued by agents, Neo winds up in a hotel corridor, where he finds he is able to stop approaching bullets with the force of his mind. Prop bullets provided by production were scanned, then mapped onto digital geometry by Manex. Like the bullets themselves, rings of color surrounding each slug’s wake were computer generated. Deformation of the 3D background created the wake effect, which was enhanced with 2D refractive and reflective effects and a filter that further warped the background.



After a lengthy battle with Agent Smith, Neo is pursued by all three agents- winding up back in the same anonymous hotel Trinity had fled in the movie's opening. Agent Smith deals Neo seemingly mortal bullet wounds; but with the realization that he is truly "the one," Neo rises and looks down the hallway at the agents with eyes capable of decoding The Matrix and seeing it for what it is- computer code. Animal Logic produced

the effect. 'Animators rebuilt the hotel corridor in Softimage," Lynne Cartwright recalled, 'using tiles of the cascading wave code- just like the code seen at the beginning of the film- to cover the walls and the floor. We integrated highlight and shadow aspects of the live-action corridor into our 3D hall, letting them play over the letters of code." Denser codes were used to cover the agents, while progressively lighter codes in more distant areas of the frame forced the perspective of the hallway.

Neo stops additional gunfire from the agents with the force of his mind, then launches himself at Agent Smith, diving inside the sentient program's husk and exploding it from within. Keanu Reeves was shot against greenscreen for his leap, and that footage was combined with a 3D element of Hugo Weaving. 'We built Agent Smith's stomach in 3D," said Cartwright, 'which had to react like a body being tackled forcefully. There were shadow passes for the fabric of his shirt and suit that we could break out from different compositing elements, allowing control to be maintained across all these different layers."

Once Neo has penetrated the program's human form, Agent Smith's face and hand begin to form boil-like pustules. High-resolution textures were created for these distorted areas. The 3D agent model was then manipulated, with the original plates projected back onto the boil-enhanced geometry, and image warping employed to make the 2D plate image conform. But a straight-from-the-box stretching effect proved unrealistic for skin- resembling drops of water instead of boils- so a procedural approach was implemented that allowed skin to stretch in accordance with the amount of surface displaced by each boil. Comped on Cineon, the boils also featured multiple light and shadow passes to create a full dynamic range of highlights and lowlights.

Agent Smith explodes into nothingness, leaving Neo stand-ing alone and triumphant before the other agents, who quickly flee. The nature of Agent Smith's disintegration required considerable thought. 'We had to figure out what this computer construct that walked like a man looked like on the inside," observed Cartwright, 'and found that analogies helped clarify matters. After suggesting that he might be like a watermelon inside, with lots of squishy stuff, we finally settled on Agent Smith as a coconut- a hard shell on the outside, with a thin white inner layer that disintegrated off into Matrix-green phosphorescence as he exploded."

The 3D Agent Smith- based on a casting of Hugo Weaving- was split into sections and animated in Houdini. Houdini also permitted programmers to create trails and light glows spreading from individual pieces flying across screen. These elements ranged from very tiny dust-like particles

Sentinels breach the hull and invade the Nebuchadnezzar, where Trinity awaits Neo's exit from The Matrix. To better integrate the CG sentinel within the live-action set, set pieces rigged to interact with the creature were shot separately against greenscreen. After mattes were extracted from the greenscreen elements, they were mapped into the Maya scene file, allowing for genuine on-set shadow-and-light qualities to play off the sentinel's form.

and small fragments that were handled procedurally to medium-sized chunks and big foreground pieces requiring hand work. ‘Unlike a straightforward comet streak effect,” Justen Marshall remarked, ‘the Agent Smith pieces featured dynamic tumbling action as they moved through space- so the trails generated couldn’t just be straightforward streaks. Plus the inner surface was burning and emitting phosphorescent gas. When the burn side faced forward, the trail had to dissipate and drop off, then reappear as the piece rotated.”

Back aboard the Nebuchadnezzar, marauding sentinels have breached the hull and invaded. ‘After they break through the hull, almost everything that the sentinels interact with- from grates that get pulled up to the chairs being knocked about — was shot on set by John Gaeta,” said Jamie Pilgrim. ‘The grates were shot greenscreen, so we could pull a matte and position a CGI plane appropriately within the Maya scene, with the plate image mapped on so that I could make the sentinel strike precisely at the sides of the hole cut in the grate. While rendering, I could use the mapped plane to throw shadows from the grate onto the sentinel.”

Just as Neo transfers safely back into his physical body on board the imperiled craft, the humans’ electromagnetic pulse weapon destroys all sentinels in and around the ship. ‘The wave of destruction was supposed to have the look of a gigantic underwater atomic blast,” stated Al Arthur, ‘but it also needed a “techno” feel to make the pulse relate visually to other design elements throughout the film- namely, colder colors and lots of lightning.” Concentric blast rings of smoke, created using particles, preceded two principal blast bubbles made from particle bobbies and rendered with animated texture maps that produced waves of distortion. A prismatic layer with animated texture maps below the distortion surface was also done with bobbies, while internal vapor layers included smoke trapped within the currents of the EMP blast. Several lightning layers utilized Arthur’s algorithm for complex geometric branching, which also saw use in the earlier phone teleportation.

The film concludes with Neo reentering The Matrix universe to give the machines notice that their reign will soon be at an end. He gives proof to that claim with a demonstration of his mastery over this environment, flying off to begin the process of awakening the human race to its actual condition- accomplished with greenscreen footage of the actor composited over a tiled location cityscape. The events to come beg depiction in one or more sequels, especially given the extremely favorable public response to the film.

The studio’s own favorable response to an early screening of The Matrix prompted a decision to release the picture early in 1999, rather than the late-summer date that had been previously mandated due to blockbuster competition. The effects assignment was impacted by this decision, with the schedule change compressing the post effort and adding millions to the budget. Even so, the film still came in below \$70 million- a bargain, as production costs were recouped scant weeks into its domestic run.

The Matrix’s visual effects solutions served to open up all sorts of possibilities for future productions. ‘The virtual background approach we’ve helped pioneer is going to take time and research to fully develop,” John Gaeta acknowledged, ‘but eventually it will give way to true 3D filmmaking. That has become possible due to the revolutions in measurement technology and computer graphics- which are converging now that engineering industries have realized the

benefits of virtual depictions. Measurement is on a collision course with photoreal CGI, and virtual reality is the synthesis of these two technologies. But that's just the technical end. The coolest part of The Matrix was that we could capture the best in nature, shooting reality in the form of locations and sets, then attach our own stylization atop that, transforming real-world imagery in a way that lent a sense of authenticity to these virtual backgrounds. The techniques used to depict the movie's defining moments were, in a sense, what the movie was all about."

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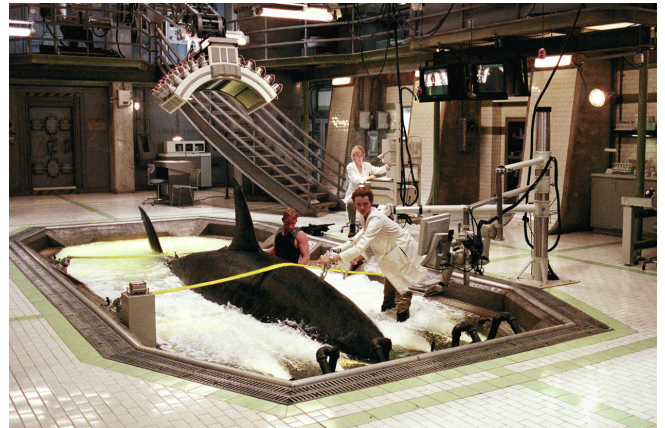
DEVILS IN THE DEEP BLUE SEA

image

ARTICLE BY ESTELLE SHAY

In the summer of 1975, seaside resorts worldwide suffered a slump in business as a result of a Universal Studios release about a man-eating shark and its reign of terror in a small New England beach town. Destined to become a horror classic that would put a young, novice director named Steven Spielberg on the map, *Jaws* so thoroughly traumatized an already shark-phobic public, it sent millions scrambling for dry land. Ironically, the reel-life object of all the fuss was considerably less impressive than its top-billed screen persona. Spielberg's cinematic star was, in fact, a temperamental robotic creation so unconvincing in its performance, its presence on screen had to be limited to judiciously edited snippets.

Twenty-five years later, with the release of Warner Brothers' *Deep Blue Sea*, audiences are once again coming face-to-face with the cold, dead eyes of one of nature's most lethal predators. But this time technology was up to the task of bringing terrifyingly real sharks to the big screen. In the script by Wayne and Donna Powers- reworked from an original screenplay by Duncan Kennedy and John Zinman- the villains of *Deep Blue Sea* are genetically enhanced supersharks, bigger and far more aggressive than their naturally spawned counterparts, and uncannily intelligent. Their fifty-million-year Evolutionary leap is the result of experimentation on board the *Aquatica*, a former submarine refueling station retrofitted for oceanographic research. There, scientists have been conducting highly unorthodox- and some would say unethical- experiments on captive mako sharks, hoping to increase the size of their brains



Hyperintelligent sharks match wits with humans in *Deep Blue Sea*. The action thriller from director Renny Harlin explores the consequences of unbridled genetic engineering on the *Aquatica*, a floating research station whose scientists are involved in questionable, though well-intentioned medical research. Engaged to lend his considerable expertise to the project was animatronics ace Walt Conti, whose Edge Innovations created cutting-edge robotic sharks for use on elaborate full-scale sets.



Aquatica shark wrangler Carter Blake (Thomas Jane) is stalked by a tiger shark, one of several computer generated sharks created by Hammerhead Productions to work in concert with the Conti animatronics.

and facilitate the extraction of a rare protein complex that they believe will result in a cure for Alzheimer's and other ravages of human aging. Things quickly get out of hand when the largest of the sharks, a twenty-five-footer, launches a vicious attack on a member of the scientific team. A rescue helicopter attempting to evacuate the injured man crashes into the Aquatica during a fierce storm, and soon it is the sharks who are in control of the rapidly sinking habitat. Stalking their human prey with cunning, the intellectually enhanced ocean predators begin a cat-and-mouse game aimed at winning their freedom and exacting a deadly revenge.

Deep Blue Sea had been in development at Warner Brothers for several years before noted action film director Renny Harlin was signed to helm it. Harlin, best known for such high-voltage thrillers as *Cliffhanger* and *Die Hard 2*, was intrigued by the prospect of venturing into new cinematic territory. 'I've done big action films,' Harlin noted, 'but this was more of a horror film than an action film. Although it does have some big-scale action sequences, what we were trying to do was the first large-scale horror movie since *The Shining* or *The Exorcist* or *Jaws*. There have been a lot of low-budget horror films with a certain tongue-in-cheek mentality; but with all due respect to those films- which have been very successful- we wanted to make a seriously scary horror film with believable characters and situations so that audiences could be scared in a big way. I felt that was a different kind of challenge for me.'

Even before signing Harlin to the project, Warner executives had sought out the talents of large-scale animatronics expert Walt Conti, the wizard behind the robotic whales and dolphins in such films as *Free Willy*, *Star Trek IV* and *Flipper*. Harlin found considerable reassurance in Conti's proven track record. 'Walt was crucial from the beginning,' Harlin observed. 'I had been apprehensive about how we were going to make these sharks work, especially working in water and dealing with the problems that come from that. We all agreed that Walt knew more about this area than anybody else. So we went to look at his shop and saw the insides of some of his creations and how unbelievably complicated and sophisticated they were.'

Conti was equally enthused by the idea of creating the creature that had given *Jaws* its bite, but this time with the advantage of sophisticated animatronics technology. 'Ever since we built the first free-swimming killer whales for *Free Willy*,' Conti observed, 'people have said, "Just think what they could have done with *Jaws* if they'd had these things.'" So it's always been in the back of my mind that if another big shark film came along, I had a responsibility to do it. But this film wasn't merely trying to duplicate *Jaws*. These sharks are not just out swimming in the ocean. They show up in flooded areas of the human habitat- in kitchens, claustrophobic corridors and bedrooms. So there was the added logistical challenge of integrating our sharks into all of these very cool sets.'

With Conti's participation in the project assured, Harlin next enlisted the services of another key effects artisan, one with whom he had enjoyed a longstanding relationship. Visual effects supervisor Jeffrey A. Okun had proven himself indispensable to the director on four previous movie outings, including *The Long Kiss Goodnight* and *Cutthroat Island*. Having just completed some four hundred effects shots for *Sphere*, Okun agreed to head up Deep Blue Sea's visual effects unit, coming on board the project in February 1998, at the start of its five-month-long preproduction phase. Harlin had sought Okun out because of his hands-on approach and his knack for squeezing the most out of an effects budget- in this case, a conservative one

considering the scope of the movie. "There are many ways to do a film," Harlin noted. "The most expensive way is to take your script and drop it in the lap of a big visual effects house, and say, "See you next Christmas.' It's like going to a furniture store and saying: "Here's my home-furnish it and call me when it's done.' Then there's the Jeff Okun way. With Jeff, you can sit down and look at a storyboarded sequence, and say: "This is what I'm trying to achieve. How do you think we should do this?' And he will say: "Well, you have three ways you can go. You can shoot this for real and that for real. This can be miniature, and this can be bluescreen.' And together, we design exactly how it's going to be done. Then he finds a whole bunch of companies that are tailor-made for a particular effect, and he'll ask each one to give him their best bid for, say, twelve shots. Then he manages all of these various satellite companies, circling between them and coming back with animatic samples of how it's all going to look. Jeff has incredible imagination and ideas. It's never happened that he didn't come back with something even better than what I was asking for. He's really the creator of all the effects."

Working with Harlin on the storyboarded script, Okun began breaking down the effects work in terms of specific shot requirements. While the shot count would eventually reach 481, initial estimates fluctuated wildly from 193 to 850 shots as the screenplay went through a series of rewrites and refinements. "I'd offer up possibilities that were doable within the budget," recalled Okun, "so that Renny could go back to the writers and say: "Instead of this, see if you can make something cool this way.' Though I never saw a writer, it was like being involved in the writing process. Renny was very receptive to different approaches and new ideas. For example, at one point they were going to crash a plane into the big shark to kill it, but that was extraordinarily cost-prohibitive. So we came up with a different approach, one that was not only less expensive but also more personal to the story and less glorified. That sent the writers down a whole other path." Despite the budgetary constraints, Okun was determined to break new ground in terms of the effects. "We spent a great deal of time looking at all the sea films and horror films ever made, and Renny and I would have long discussions about why things worked or didn't work."

Okun and visual effects producer Thomas Boland also canvassed the visual effects community with an eye towards divvying up the anticipated shot load among a variety of vendors. Miniature work to augment the live-action sets was assigned to Grant McCune Design, with David Stump designated as miniature effects director of photography. For digital sharks that would be used in conjunction with Conti's practical versions, Okun was won over by the enthusiasm of a small company- aptly named Hammerhead Productions- which he designated early on as the show's primary digital shark vendor. Another early recruit was Flash Film Works, responsible for ocean simulation and the creation of digital storm effects for a key sequence. Cinesite, given more than half of the overall shot load, provided umbilical and shark rig removals, greenscreen compositing and an array of CG effects, in addition to handling all of the film's scanning and recording needs. Other vendors lending their support included Digital Film Works, VisionArt Design & Animation, Manex Visual Effects, Modern Video Film and the London-based Film Factory and Men in White Coats. Finally, in an eleventh-hour push to meet the film's July 30 release date, Industrial Light & Magic was assigned several segue shots and an add-on sequence for the revamped finale.

Besides assembling their core creative team, the filmmakers addressed the procurement of a filming site that could handle Deep Blue Sea's complex, water-driven shoot. Fortunately, such a locale existed in Mexico, near the Baja California resort town of Rosarito- only a three-hour drive from Los Angeles- where Twentieth Century Fox, two years earlier, had erected a production studio equipped with tanks and stages built on a hundred-acre tract overlooking the Pacific. Custom designed to accommodate the outsized production demands of James Cameron's Titanic, and touted as the premier site for water-related filming, Fox Studios Baja offered the ideal setting for Harlin to navigate the tricky waters of his own seagoing opus.



At Fox Studios Baja, in Mexico, Renny Harlin and Walt Conti attend to one of the production's three full-size mechanical sharks.



Edge Innovations art director Jonathan Horton and sculptor Wilson Kwok confer on the detailing of a fifteen-foot mako shark- designated a Gen 1 variant by the Aquatica scientists..



Under the direction of model shop supervisor Dave Caldwell, Conti crew members prepare a sculpture representing the even larger Gen 2 for molding.

With filming slated to commence in mid-July, construction crews in Baja began work on a series of elaborate sets and set pieces. The studio's mammoth 360,000-square-foot outdoor tank, which had been custom-built to accommodate the nearly full-size Titanic, was earmarked for Deep Blue Sea's signature set- a full-size representation of the above-water Aquatica. As in the case of Titanic, the surface tank- which faced the open sea- would make it possible to film the set in such a way as to sell the illusion of a habitat surrounded by ocean. The finished Aquatica set, which took up a substantial portion of the eight-acre tank, measured some 350 yards in length and was built to resemble the bunker-like, poured-cement, no-frills look typical of military installations. It consisted of several research buildings, plane and boat docks, along with a multitiered central structure- dubbed "the wedding cake"- that contained a control tower and lookout station. Surrounding the compound were enormous aquatic pens accessed by catwalks and perimeter walkways. The entire complex was constructed as a mirror image of itself along a central axis so that camera crews could, theoretically, film the set from any direction and still be shooting toward the ocean.

On Stage 2, housing the biggest and deepest of the studio's three indoor tanks, crews erected the interior set for Aquatica's "wet lab"- the sophisticated medical laboratory where shark experiments are conducted. Ostensibly the first of several habitat sub-levels extending deep into the ocean, the wet lab was built on a hydraulic riser so that it could be raised and lowered into water. The remainder of the film's sets were constructed on Stages 3 and 4, with the former housing several sub-level corridors and the interior of Aquatica's control tower, and the latter containing a main corridor set, kitchen set and crew members' quarters. In a smaller outdoor tank, adjacent to the big one, a variety of lesser set pieces- both interiors and exteriors- were built for closeup work featuring Conti's sharks.

Some two months before the arrival of the film crew, special effects supervisor John Richardson and a twenty-three-person team joined the frenzied preparations in Mexico. 'John had done



At the deep end of the Baja studio's outdoor tank, the on-site animatronics team checks the Gen 2 for buoyancy. All three of the mechanical sharks were capable of free-swimming movement.



For scenes requiring more forceful action, the versatile creations were mounted on giant motion bases, also designed and built by Edge Innovations.

second unit and miniature work for me on Cliffhanger,” Harlin commented, ‘and halfway through that show had taken over the whole effects department- and done a fantastic job. He’s very methodical and prepared, and I had always wanted to work with him again.” Having joined the production in January, Richardson had taken advantage of script-related delays to work out the budget and particulars for what promised to be far more than just run-of-the-mill stage effects. While nearly all of the sets would require some degree of flooding, the biggest task entailed preparing the outdoor tank for one of Deep Blue Sea’s most compelling scenes- the arrival of the fierce storm that sets in motion the chain of events leading to Aquatica’s destruction. Jeff Okun’s strategy was to capture as much of the storm as possible on the outdoor set using practical stage effects, then rely on CG to intensify the illusion. Richardson surrounded the big outdoor set with a battery of storm-making equipment- lightning-strike generators, huge rain towers, six large wind machines, six tip tanks, two water cannons and four wave machines. ‘Some of the equipment we rented, some we already had, and some we had to manufacture,” Richardson related. ‘We built the tip tanks- which could dump about 1500 gallons of water at a time over various parts of the set- the water cannons and two hydraulic wave machines, designed to generate bigger-than-normal waves.”

Meanwhile, preparations of a different sort were underway at Conti’s pioneering animatronics company, Edge Innovations, where a crew of seventy-five- more than double the usual staff- had been laboring for nearly ten months on the mechanical sharks that would inhabit the Baja tanks. Conti knew that the characteristics that had long given sharks their reputation as one of the most feared predators of the sea were by no means going to be easy to duplicate mechanically. ‘I’ve been a diver for years,” Conti said, ‘and I’ve always had respect for sharks. They are amazing killing machines. Anything that moves that well and that quickly and can come on you in a second from nowhere deserves a certain amount of respect. And when you have to really get in there and try to copy that, it takes that respect to a whole new level.”

High-level performance demands meant that the animatronics would have to mimic a full range of shark behaviors. ‘Our sharks had to be able to come to the surface, dive and swim,” Harlin elaborated. ‘They had to move their eyes, their gills and their fins. They had to be able to bite on things, carry people in their mouths and break through doors.” Having researched sharks



Custom-built for water-related shooting, Fox Studios Baja- with its submersible stages and enormous tanks - proved the ideal location for Deep Blue Sea’s aquatic action. An aerial plate reveals the movie’s signature set- a full-scale representation of the above-water Aquatica, erected in an outdoor tank overlooking the Pacific Ocean.



Flash Film Works utilized the plate for an early establishing shot of Aquatica, as seen through the window of an inbound sea plane. Digital artists painted out camera trucks and the tank edge in the shot, replacing the real ocean with Areté computer generated water. A still image of the airplane’s window, taken from inside the cockpit,

extensively in preparation for the picture, Harlin also insisted on animatronics that duplicated a shark's unique jaw physiology. 'One of the things I

and another of its wing struts were subsequently composited into the shot.

noticed when I looked at documentary footage was the way a shark's lips seem to peel back when it bites. It's actually the jaws- which are not connected to the head, but kind of floating- that extend out and give the appearance of the lips pulling back and gums being exposed. So I said to Walt: "This is what I want to see. This is the scary thing about sharks, and what makes them look so unbelievably menacing. Our sharks have to be able to do that when they get ahold of something and start ripping and tearing it apart."

Speed was another essential performance issue, since the sharks in the film were dreaded makos- the fastest swimming predators in the ocean. Conti also knew that his mechanicals would be filmed overcranked to slow down the action and create a sense of scale. 'Most documentary footage of sharks is shot high-speed," Conti observed, 'and people are accustomed to seeing that. If you saw this stuff shot at normal speed, the shark would look like a toy."

In a test of its ingenuity, the Edge Innovations team devised a new breed of hydraulically powered animatronic that was both a testament to the company's past successes and a quantum leap forward in terms of power and engineering. 'These sharks had, by far, the highest power density of any animal we have ever built," stated Conti. 'They were more powerful than the average car- and it showed up when they moved. None of the things we built in the past could move at these rates. Just getting enough power density in there to have a shark snap its head and attack quickly required some very high stresses and loads and exotic materials."

Three full-size animatronics were built. Two of them, capable of being operated simultaneously, represented the scientists' first-generation specimens- designated "Gen 1s"- which were intellectually enhanced, but still ordinary-sized, fifteen-foot-long makos. For their abnormally large successor- the Gen 2- Conti devised a twenty-five-foot version that differed from the others only in size. 'One of the biggest challenges," Conti observed, 'was making these things neutrally buoyant- everything we were putting inside it was heavier than water, and at some point the thing would sink. We had to use high-strength steels, aluminums and titaniums- materials that had the highest strength-to-weight ratio. Everything needed to be stress-analyzed and maximized in terms of efficiency and weight. We were dealing with almost aircraft-engineering-level issues, trying to make the sharks as light as possible without spending a fortune on materials."

Exterior skins were fashioned in durable urethanes designed to withstand the rigors of saltwater exposure and move realistically over the exoskeleton. Some silicones were used in areas where translucency was important, such as the mouth and its interior. To simulate a shark's unique jaw movement, the skull was fitted with a floating jaw that provided an added level of articulation in the teeth and gums. 'Up until now," remarked Conti, 'people made sharks with a simple mouth that opened and closed and had big teeth. Instead of having the teeth permanently mounted in the skull, we created dentures that fit inside it to create a double-acting movement." Cast from rubber molds, the teeth were created in multiple sets so that backups would exist in case any were damaged during filming.

To accommodate Harlin's kinetic directing style, Conti fashioned his sharks for maximum versatility. Tethered to an umbilical, they could free-swim at speeds of up to ten miles per hour. As an alternative, they could be mounted on their own high-performance motion bases that Conti and crew custom-built from scratch and installed in the Baja tanks. 'A lot of people have used motion bases in the past," Conti said, 'but nothing made for underwater use. Also, most bases are designed for roll and pitch and yaw motion, whereas ours needed to strike and lunge. So we built these huge seven-axis motion bases that our sharks could be mounted on to do very precise computer playback motions. It was our first time with motion bases, and we were trying to push the envelope in terms of range of motion. It's very simple to do things that move a little bit in multiple axes, but to get huge moves very quickly was a challenge." A third means of locomotion was a hydraulically powered track system installed in the Baja tanks by the Edge Innovation crew. Equipped with a three-axis articulator-type mount designed to mimic the swimming motions of a real shark, the system could propel the sharks down flooded corridor sets at speeds of up to thirty-five miles per hour.



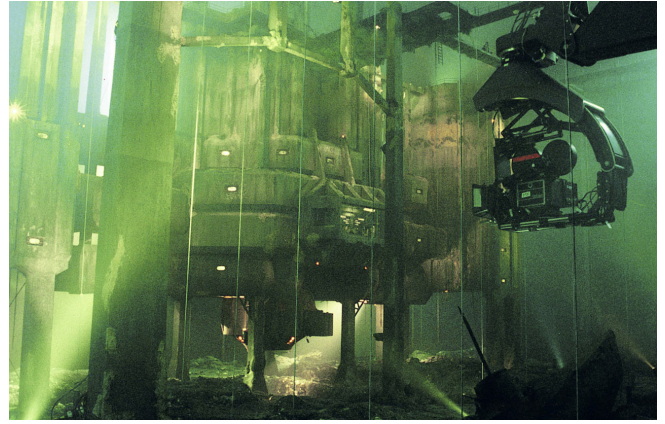
Visual effects supervisor Jeffrey A. Okun, a frequent Renny Harlin collaborator, joined forces with the director to conceive more than four hundred effects shots, then assigned and oversaw their execution at nine different visual effects houses.

Several miniature mechanical sharks were also built by the Conti team. Operated with hair-thin cables, the six-foot-long minis proved especially useful to Jeff Okun, who used them for both Gen 1s and the Gen 2 in a number of forced-perspective shots staged during the live-action shoot. "They moved unbelievably well," Okun stated, "and they were faster, more natural and much safer to be near than the larger ones." Other animatronics provided by Conti included several partial constructs- specifically a Gen 2 mechanical head and a half-body for filming in some of the smaller tanks unable to accommodate the entire model- and remote-operated dorsal fins with electric thrusters. Interchangeable shark skins were also fabricated for scenes in which the mechanical makos needed to take on the appearance of a different species of shark.

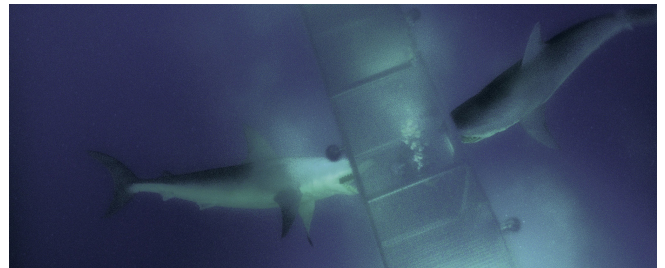
Conti and twenty of his crew were on hand to operate the robotics as principal photography for Deep Blue Sea commenced in Rosarito. Donning wet suits, Conti and his shark wranglers found themselves operating in two distinctly different modes, depending on which form of shark locomotion was required. "In free-swimming mode, it was basically just two of us underwater with joysticks, controlling the things- similar to what we did with Free Willy," Conti explained.

Maneuvering the big sharks was by no means a simple undertaking, however, since operators were dealing with a five-inch-thick, three-hundred-foot-long umbilical. "These umbilicals cannot take a twist, so a key thing was keeping track of which turns were made. For every clockwise turn, we had to make a counterclockwise one, and we were continually battling with it and making sure we didn't tangle it on something. Still, it was pretty amazing to see one of these robots actually swimming. If it was balanced just right, and ballasted and kicking just right, it was ninety percent there, in terms of performance."

While the tethered mechanicals worked best for underwater views of the sharks swimming, shots calling for dynamic surface actions, such as thrashing or attack moves, were achieved with the animatronics mounted on their motion bases. Eighteen axes of movement could be programmed into the motion bases, then played back and edited via a Macintosh setup that utilized Edge Innovations' custom software combined with an integrative package by Mediamation. "We'd lay in gross body movement first," Conti explained. "Then we could go back



Underwater views of the habitat's sub-surface wet lab made use of a sixteen-inch-scale miniature, built by Grant McCune Design and shot motion control on a smoked stage.



A submerged titanium tunnel protects Carter Blake from an attack launched cooperatively by two intelligence-boosted Gen 1 sharks. Hammerhead executed the shot, using its CGsharks in combination with a tunnel element extracted from another plate and extended via a matte painting. Air bubbles trailing from the diver and ocean particulates were added CG elements that helped sell the undersea illusion.

and layer in the movement of the mouth, the upper and lower jaws, the teeth, both eyes, the gills, the tail and all that. It was multitrack recording, over and over and over- but the beauty was that you could just turn up the speed knob, and crank up the performance.” Coordination was essential for a believable performance. ‘When we were not in sync, it looked like a spastic robot. But when we got it right and played it back overcranked and really slow, it was amazing. It looked like the real thing.”

Once the performances were recorded, finessing or altering them was a relatively simple affair. ‘There were many times we recorded things in advance,” said Conti, ‘and then on set they would make a change, and say, “Well, we really want the teeth to do a double bite.’ We’d be able to do that between camera setups. So they weren’t absolutely locked into every move. One of the trickiest things, though, was motion base moves where we were trying to interact with intricate sets. It was not just a matter of hitting a mark- we had to hit the mark and get there in a believable “shark’ way. It was just like puppeteering.”

Safety was paramount when it came to operating the enormously powerful robotics on the live-action set. Weighing in at four tons, the Gen 2 model had a thousand-horsepower engine in it, capable of delivering several thousand pounds of thrust, and could function in full-hydraulic lockout. Such power levels demanded that numerous precautions be taken to ensure that shark interactions with actors and stunt people never got out of control. ‘Even the smaller sharks were designed to carry a two-hundred-pound stuntman in their mouths and thrash him from side to side,” stated shark design engineer Peter Fletter. ‘We looked closely at what we needed to do to protect against whiplash, and tried to keep the performer’s head heavily supported and the speed down so we didn’t thrash too seriously.” The massive jaws, capable of chomping down with destructive force, could also be set for hard mechanical lockoffs, or stops, to keep them from closing beyond a specified point. Even more dangerous than the sharks were the motion bases, the biggest of which weighed about ten thousand pounds. ‘We had levels of emergency cutoffs that could slam the thing shut. We had redundant feedback and a whole level of protocol as to how we operated it on set. People tended to think, “Oh, it’s just a fake shark.’ But the motion bases could drive those sharks right through a set- right through anything. We wanted the power and the speed, but we had to control it.”

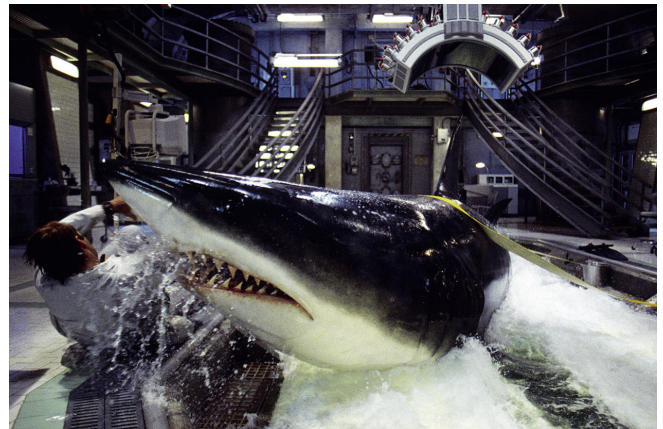
With most of the sets requiring some degree of flooding or submersion, and without enough tanks to handle the load, both Conti and Richardson often found themselves juggling setups as they leapfrogged from one tank to the next. Sets often were erected, filmed, then had to be torn down to make way for new ones. ‘We had sharks in sets and sharks out of sets,” explained Richardson, ‘and sets that had to have different depths of water depending on which sharks were being used in them. It became a logistical nightmare.” Flooding of sets was achieved either by dumping water into them from tip tanks or from giant water chutes, or by lowering them on a hydraulically operated riser into a water-filled tank. ‘My crew controlled the riser platform, the water sprays, tip tanks and so on- any time water had to be moved, sprayed, splashed or operated.”

Not surprisingly, unforeseen problems occasionally arose, such as the discovery that the studio’s filtration system could accommodate only one tank at a time. ‘What that meant for us,” remarked Okun, ‘was that we had to be really careful how we planned our shooting schedule

and who was going to be in what tank, at what stage and when; because the water would get so dirty, we couldn't shoot in it. That happened to us a couple of times, and we had to go to an alternate plan. Mike Meehan, who was our water management guy, did a brilliant job of managing all that stuff." Another glitch involved sight-lines on the outdoor tank. Situated adjacent to the ocean, the tank had been designed for shots that were either at basic eye level or at least two to three stories high, looking down, so that the edge of the tank would be hidden from view. 'All our shots, though, were at first-story or second-story levels, and you could see the edge of the tank in every one of them- which was something we had not counted on.' The situation would be remedied on a shot-by-shot basis during postproduction, with 3D sequence supervisor Sean O'Connor at Cinesite creating seamless blends between the tank water and the ocean.

While the production wrangled with full-size animatronics in Rosarito, an entirely different effort was underway at Hammerhead Productions, where resident visual effects supervisors Rebecca Marie and Jamie Dixon, technical supervisor Thad Beier and producer Dan Chuba were tasked with creating computer animated sharks that could duplicate the practical ones being shot on the live-action set. Though Renny Harlin had intended to push Conti's creations to the limit, there were still things the animatronics could not do. They could not, for instance, gobble up an actor- or bite him in half. They could not be filmed from certain angles, or doing 180-degree turns. It was also difficult to get distant shots of them swimming toward camera because the tanks were not always deep enough. Such shots automatically became the province of CG.

Rebecca Marie- a lifelong shark enthusiast who had spent years collecting shark-related paraphernalia- could scarcely contain her delight at the chance to freely indulge her obsession. 'We did a test early on, before we were even awarded the work,' Marie recalled, 'just to show Jeff what we could do. We got a shark model and put it in some footage of tropical fish that Jamie had shot with an underwater camera when we were down in Baja. Even though it wasn't a match with their practical shark, Jeff and Renny thought it looked great.'



Following a successful test of a procedure to extract medically valuable proteins from the enlarged brains of the genetically enhanced sharks, the suddenly revived Gen 2 launches an attack on research physician Jim Whitlock, who is standing by the wet lab pool. Staging of the pivotal sequence was accomplished on an indoor set with a stunt double for actor Stellan Skarsgård- fitted with a detachable prosthetic arm- interacting with the Gen 2 animatronic on its custom motion base.



A violent storm batters the Aquatica as a rescue helicopter attempts a perilous evacuation of the critically injured scientist. Wide views of the

Upon winning the assignment, Marie and Beier began experimenting with a generic shark model obtained from a company called Zygote. Using photographs of Conti's sharks taken from every conceivable angle as reference, they tried to

modify the generic CGmodel. 'We were hoping to

use this model for more than just testing in the beginning," Beier noted, 'but it really didn't match the mechanical sharks very well. I tried to nip it and tuck it, but the more we looked at it, the more we decided it just wasn't going to work. So, since we don't do a lot of model building here, we commissioned Viewpoint to build a model to our specifications. They took all the reference photographs we had and built a clay sculpture, which they digitized. That shark model came much closer to matching the mechanical one."

While they awaited completion of the new model, Marie and Beier continued their experiments, laying out parameters for texture-mapping the surface of the shark, hand-painting the textures in Photoshop and addressing issues related to simulating a water environment. Concurrently, Beier turned his attention toward developing custom controls for Hammerhead's proprietary animation system so that key aspects of the shark performances could be addressed procedurally. The software program was one that Beier had developed for Shadowbuilder, a small independent film directed by Dixon the previous year. 'I had felt that a lot of visual effects animation required very powerful procedural language to describe an effect," explained Beier. 'Several of the newer packages, like Maya and Houdini, have ways of building procedural stuff into their systems, but it really seems like an afterthought in their interpreting languages- which means they run more slowly. Also, they're very much circumscribed languages that only give you a little bit of power- plus they are very expensive. So I wrote an animation system that uses the scripting language of "C"- which is a full and powerful programming language, and the most popular one in the world- and we combined the power of that with some interactive flexibilities.

'In terms of the shark animation, we wanted to capture all of the subtle things that make a shark look like a shark, but still free the animator from having to put all of that into the performance. A shark's motion when it swims, for instance, is very complex. Its body from the shoulder on up is rigid, while the rest of it is increasingly flexible; and as it turns, the body bends into the turn and rolls. What I did was take all of that intelligence and put it into the programming script. The animators could just point the shark along a path and have it swim, without having to go in and animate every bend and twist. And if the director came in, and said, "Can it swim a little faster?" or "Can you beat its tail a little more?," they could quickly turn around a new shot by just doing a new motion- and everything else would automatically follow."

While such technical challenges proved relatively straightforward, the difficulties, as Hammerhead animators would discover, lay in making the shark animation sufficiently exciting. Brought on board to oversee the effort was Theresa Ellis, a freelancer with fifteen years of animation, 3D compositing and effects supervisory experience. Working with Beier, Marie and a team of six to seven animators, Ellis quickly learned that duplicating shark movement was not as simple as one might think. 'The gills had to move, the eyes had to move, the muscles in the

surface mayhem- created by Flash Film Works- made use of a digital Aquatica model and computer generated ocean, enhanced by rain and breaking wave elements. Matte-painted skies and 3D searchlights were among The Many details layered into the composites.

cheek had to bulge when it chomped on something; and because we were seeing it in closeup, the color and lighting on the teeth had to be just so. The gum movement, especially, had to be very realistic, because that was what was in your face when it killed. We had numerous National Geographic videos where you could see closeups of how a shark attacks. It has to grab on and wiggle and shake its prey to saw through the skin. All of that had to come through in the performance.”

As soon as scanned footage from the live-action shoot became available, the animation crew began working on specific scenes, employing a gray-shaded version of their shark model. Procedural controls built into the programming script could be customized to address the specific needs of each and every shot. ‘We would look at a shot,” explained Beier, ‘then ask the animator what kind of controls he wanted to have. Then we’d customize an animation script so the animator could just plug in numbers to do the creative part. For example, if the shark had to impact with something and a wave-like ripple had to flow down his body from the impact, I could build in a little procedure that described that wave and gave the animators controls to vary the height of it, the rate and the timing.”

Once the animation was fine-tuned and approved, the digital shark was rendered in RenderMan, lit and composited into the background plate photography- a task requiring substantial digital finessing in order to integrate the creature into underwater environments. ‘Rendering and compositing the sharks was a whole second procedure,” remarked Ellis. ‘There’s a lot more to it than just the functionality of the shark; there are all the lighting and color issues to fit it in the scene. We began with a giant list of all the things that needed to be created. We had to add depth filters- what we called fog- to make it look as if the shark was actually swimming through water. So it would start out very murky, very shadowy, very dark looking- and as it got closer to camera, the details would emerge. Even within the shark itself, it had to look deeper in the murk of the water toward the back part of its body than the part closer to camera. Then there were bubbles, particulate flowing over its body as it gets closer to camera, shadows, caustics- which are the rays of light shooting through the water from the surface. All of these things affected every shot.”

Hammerhead was not the only vendor that had been laboring for months in the digital arena. From the start, Harlin and Okun had envisioned the storm scene as a pivotal moment in the film- the event that would set in motion all of the subsequent action. Strategizing on ways to make it more dramatic, they had determined that while live-action filming on the full-scale set in Rosarito would make use of every possible resource in terms of stage effects, a complementary effort needed to be undertaken to produce storm effects on the digital front. The combination of techniques, they believed, would provide a tempest of truly colossal proportions. As it turned out, nearly every shot in the five-minute-long sequence filmed in Rosarito would end up requiring some degree of digital ocean replacement, plus layer upon layer of composited 3D and 2D storm- related imagery. Those and other sequences- among them a series of mostly-3D establishing shots depicting the approaching storm- accounted for some 140 shots relegated to Flash Film Works and its founder, William Mesa.

Having known Okun for years, working with him previously on Cutthroat Island, Mesa was eager to tackle the challenges of another water-related film. ‘We had just finished some water

effects for Deep End of the Ocean when Jeff called me,” related Mesa. ‘Obviously, we were going to have to delve much further on this film into the realm of 3D water and its interactivity with 3D architecture; but the work we’d been doing on Ocean was in the same vein, so at least we knew it was possible.”

One of the first tasks Mesa, visual effects co-supervisor John Mesa and 3D model supervisor Donald Myers would tackle was the painstaking 3D re-creation of the full-scale exterior set of Aquatica. Work on the digital Aquatica began even before the real set was built, with digital artists utilizing as reference conceptual art, provided by production designer Joseph Bennett, and blueprints detailing its structural layout. Aerial photographs would later be compiled by Okun and provided as additional reference. Once the set was built, Mesa and members of his team traveled to Mexico to gather crucial measurements at the site. ‘We photographed every element of the set,” recalled Mesa, ‘every doorway, every wall, all the arches and pillars, all the stairways and walkways. Rather than doing a lot of paint work, we took all of the photographs and individually mapped them onto every one of the surfaces of our 3D model. So our final high-rez model had about 700,000 polygons, with hundreds of photographic maps on it. It was detailed enough that we knew we could maneuver our virtual camera in close and fly right past sections of it, if needed.”

The 3D model would prove more useful than anyone had anticipated when problems shooting in the big tank at Rosarito mounted. ‘We had a real problem with the full-size set for all of our establishing views,” remarked Okun, ‘because of how the tank at Rosarito was situated. Also, the way the storm sequence was staged, the dump tanks and fire hoses and everything else wound up in every shot. That meant Renny could only shoot medium and closeups- no wide shots. So we ended up using the CG Aquatica all over the place.”

Concurrent with the work on the Aquatica model, Mesa had begun exploring what kinds of software tools would be necessary to create realistic turbulent seas surrounding and interacting with the habitat for the all-important storm sequence. Although Areté Image Software- the leading makers of software for ocean simulation- had captured the waters of Waterworld and gone on to refine its product even further for the digital ocean in Titanic, their software was not



An aerial view of the Aquatica station and hovering rescue helicopter was filmed from a second helicopter high above the tank set in Mexico.



Flash Film Works tracked the craft’s position in the plate photography and replaced the water in the shot with computer generated water, adding other storm elements such as ocean swells, huge crashing waves and multiple layers of rain.

capable on its own of producing the particular storm effects that Okun and Mesa had in mind for Deep Blue Sea. 'Areté is a program that was created for real-world effects," explained Mesa. 'It's capable of duplicating ocean and creating realistic shading effects if you have one light source- the sun, for example- that's reflecting on the water. But our storm, which was happening at night, had a structure sitting in the middle of the ocean with hundreds of lights all over the place that had to reflect in the water. Plus, there were lights underneath the water that had to be rendered. Arété could not do any of that." To address such critical issues, Mesa began a months-long collaboration with Dynamic Realities, the plug-in manufacturer whose software would allow the digital team to use Arété in LightWave.

Arété also began the process of customizing its software for storm effects. 'If you have a computer generated wave coming at you," explained Mesa, 'it doesn't matter if it's three or ten feet tall- it would still look like a smooth blob coming at you if it didn't have chop and all of the detail in the swell that makes it look realistic. Those are the linear rescale points- the points within the program that make the geometry push out in different areas so the light can refract off of them. Arété was responsible for fine-tuning its linear rescale tools, which we used in conjunction with displacement maps in order to create all the detail in the water." One of the primary refinements developed was a sort of backwash collision detection that allowed animators to produce realistic interaction between the digital water and 3D architecture. 'When ocean swells hit an object, there would be a ripple effect that looked like a backwash from the collision, and a forward motion if the wave was capable of moving past the object."

A means also had to be devised for generating whitecaps on the water- a task tackled by Flash Film technical supervisor Dan Novy, who created his own system after attempts to use existing software proved unfeasible. 'Dan came up with a way of creating the whitecaps in 3D and generating them in the right positions," Mesa explained. 'He tracked the highest peaks on the linear rescale points in our 3D ocean swells and added another surface map on top of those that actually clipped them all off. Then, where those points were clipped, he inserted the whitecaps- which were actually real breaking-wave elements we had shot. Those elements were mapped onto the 3D geometry to come through the areas that were clipped."

Other methods were employed to convincingly depict huge waves crashing into the habitat. 'There was no particle system realistic enough to pull off breaking waves in 3D," commented Mesa, 'and Arété couldn't really do any breaking element or curvature in the water- it could only make swells move up and down. Since the R&D needs for that would have been too great, we said, "Look, let's just take that end of it and shoot a practical element, and we'll make it work with our 3D water.' So we went up and down the coast and shot a whole series of waves crashing against rocks, and ended up actually morphing those and stretching them in ways so that they would fit around the corners of our 3D architecture, or doing some roto work to blend them in. That way, we could have our swells turn into real waves that broke against the buildings. In some shots we would add as many as thirty or forty little breaking waves, plus big waves in the open ocean, all done in that manner."

Rain hitting the surface of the ocean was realized by texture-mapping a series of photographic elements onto the surface of the digital ocean geometry. 'We rigged up a black tank, about twenty-by-twenty feet, and shot heavy chop hitting water. We got it so that the angles were just

right- you wouldn't see the actual rain coming down, all you saw were the big droplets hitting the water- and those became our tiled texture maps. We did a series of them for what it looked like far away to what it looked like close up. Then we created a displacement map from those rain maps to displace the 3D water; so you'd see the rain landing on the water, as well as physically displacing it."

In a harbinger of things to come, Deep Blue Sea opens with an attack on a catamaran by a mako shark, an escapee from the Aquatica. The scene was shot in the outdoor tank at Rosarito using one of Walt Conti's robotic sharks and a catamaran with a breakaway bottom rigged by John Richardson's physical effects team. To create the effect of the shark bursting through the bottom of the boat, Conti devised a vertical rig to hold the motion base turned on its side- a device that would come in handy for later scenes, as well, in the cramped confines of the flooded interior sets.

Summoned by the research program's sponsors to answer for the incident, head scientist Susan McAlester (Saffron Burrows) is given an ultimatum- produce immediate results or the research program will be scuttled. Boarding an amphibious plane, McAlester- accompanied by financial investor Russell Franklin (Samuel L. Jackson), who has been sent to report on the proceedings- returns to Aquatica. For a series of daylight establishing shots of the floating research station as the seaplane approaches, Flash Film Works animation supervisor Ken Stranahan and matchmove supervisor John Coates employed a 3D Aquatica and Areté ocean. One closeup incorporated an actual flyby of the Rosarito set, with tank water replaced by digital ocean tracked into the plate photography.

Wide shots heralding the imminent approach of a storm following McAlester's arrival were created by Flash Film, making ample use of Areté ocean and the 3D Aquatica model. Stormy background skies for this and some fifteen other shots pertaining to the approaching tempest were provided by lead matte painter Tim Donahue. For an elaborate crane-down that begins above the habitat and continues deep into the ocean, Flash Film tracked the camera move on a live-action plate filmed on the outdoor set in Mexico, replacing the hillside visible in the shot with 2D ocean imagery and adding stormy skies in place of existing sky. Water in the foreground was replaced with 3D water as the camera continued its downward track, revealing 3D walkways refracted in the water, 3D shark pen fencing and a 3D model of the back end of Aquatica's platform. The camera then tracked past a motion control miniature of the undersea wet lab extending deep into the ocean- a one-sixteenth scale model constructed at Grant McCune Design under the super- vision of Monty Shook, and photographed by Dave Stump in a smoked room to simulate the murky ocean depths. CG plankton and a 2D image of the wet lab interior, inserted into the model's bluescreened window, completed the shot.

McAlester's genetic tinkering on the captive makos has had some troubling side effects, and one of the earliest indications that these specimens are far more intelligent and aggressive than run-of-the-mill makos is a well-orchestrated and calculated attack launched by the two Gen 1s on a tiger shark that has been released into the holding tank. Originally, the stalking portion of the sequence was staged with a real tiger shark and two of Conti's mini-sharks, filmed in forced-perspective. For the actual attack, the tiger shark was replaced with one of the mechanicals, dressed in tiger shark skin.

In postproduction, the sequence was reconceived by Hammerhead, which replaced the practical sharks with digital versions. "The mechanical shark wasn't reacting as violently as we needed," noted Theresa Ellis, "so we animated a CG tiger shark, with the two CG Gen 1s swimming beside it. The Gen 1s then grab onto the tiger shark in an intensely vicious manner, rip its dorsal fin off and drag it down." Blood in the water was created using a smoke program written by Thad Beier and adapted by Jamie Dixon. "I'd written the code for Shadowbuilder," stated Beier, "because the big effect in that movie was where the character turned into smoke. Jamie took the smoke code I wrote for that and slowed it way down- and it made wonderful blood that looked like it was slowly snaking through the water."

Despite the misgivings of Aquatica's shark wrangler Carter Blake (Thomas Jane), McAlester proceeds with plans for a critical experiment in which she will extract a key protein from the brain of the Gen 2 shark and test its regenerative properties on human brain cells. While the experiment in the wet lab proves an unqualified success, elation abruptly turns to horror when the anesthetized mako unexpectedly revives and lunges out of its pool to bite off the arm of research physician Jim Whitlock (Stellan Skarsgård). The attack was shot on the live-action set with a stuntman double and Conti's eight-thousand-pound animatronic Gen 2 mounted on its motion base. Prosthetic makeup effects involving the severed arm were created by Matthew W. Mungle, while Cinesite supplied CG spurting blood and digitally replaced the stuntman's face with that of Skarsgård.

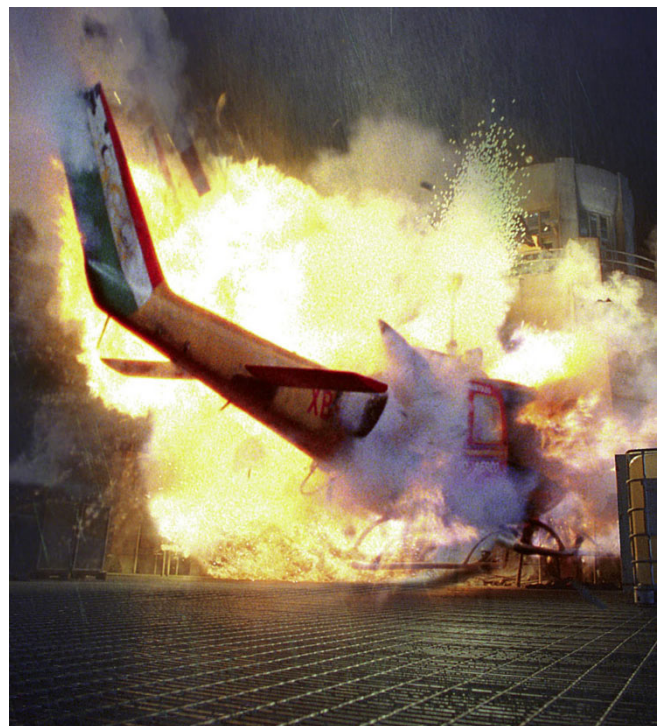
Hampered in their efforts to summon medical help by the arrival of the storm, Whitlock's colleagues arrange a nighttime helicopter evacuation for the injured scientist. Emerging topside with Whitlock on a gurney, however, the team is greeted by the full fury of the tempest, as wind, torrential rains



Unable to land at the site, the helicopter attempts an aerial rescue that runs afoul when Whitlock, strapped to a gurney, is inadvertently dropped into the sea and snatched up by the Gen 2. Tethered to a cable attached to the gurney, the helicopter is dragged into Aquatica's control tower. Shots of the explosive impact were captured on set using a full-size helicopter mockup suspended from a crane.



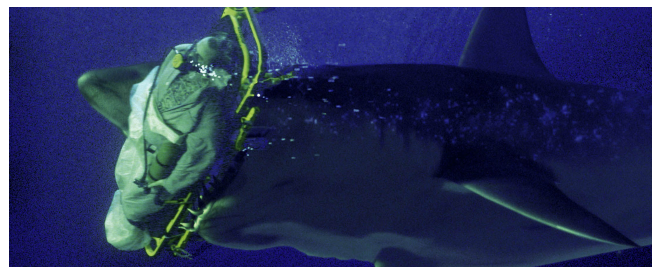
Flash Film Works removed the mockup support wires from the plate photography, then added spinning rotor blades and digital debris, plus multiple rain elements and a replacement ocean.



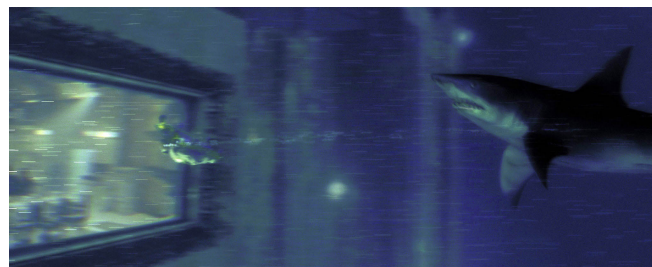
and huge waves pounding Aquatica's walkways threaten to sweep them all out to sea. Most views of the topside mayhem required the intervention of Flash Film Works. "There were some helicopter-to-helicopter plates of the rescuers coming in that were filmed above the real set," stated Mesa, "and we had to track the helicopter position, then remove virtually everything on the set- except the control tower and the docking area where the actors were standing- so that we could replace all of it with our 3D geometry. We were going to be creating storm swells breaking and going over the tops of the walkways, and waves crashing up against some of the fuel tanks- so we needed the 3D geometry for the interactivity with our 3D water. Once we replaced everything with 3D geometry, we had to roto out the helicopter, and add all our Areté stormy water and multiple layers of rain, then add the helicopter back in and put rain on top of that and in the foreground. Of course, where John Richardson's dump tanks were spilling water on the back end of the real set, we left all that in; but we added multiple breaking-wave elements over the back of that to cover the dump tanks because they were in the shots. Then we had to blend their spills with our waves to tie the images together."

Several elements were also added to the plate photography to make the rain look more realistic. "Most of the closeup stuff on the Aquatica, when the characters are out on the walkways, was shot practically using rain rigs," Mesa noted, "but the rain rigs on the real set were only hanging above the central area, whereas the whole complex extended well beyond that. So in wider shots, you were seeing all these lights with no rain illuminated in front of them. Once we started putting the shots together, we realized it did not look right because there was all this storm going on upfront, and nothing in the background. To correct that, we shot a whole series of practical rain-light elements and mapped and composited them onto every one of the lights in those scenes to give the storm a sense of depth. Another thing we realized was that to create a realistic rain effect with nighttime illumination, we had to duplicate the way that real lights generate a surrounding glow from the rain falling in front of them. And the overall lighting of the night sequences had big ring pools that needed to be lit up from the rain itself. So we had to create a

A practical of the helicopter exploding over the set continued to provide a wide view of the pyroclastic Flash Film Works added effects secondary to John Richardson's deck with digitally aligned footage of a Grant McCune miniature helicopter crashing into a crude black-box set piece configured in the shape of Aquatica.



In a knowing act of sabotage, the Gen 2 mako swims full-speed toward Aquatica's undersea window, with Whitlock and the gurney in its mouth. Hammerhead tracked its digital shark to live-action footage of a stuntman strapped to the gurney, dropped into water and filmed with the camera turned on its side. Trailing digital bubbles and ocean particulates sweetened the effect.



Stopping short of impact, the shark releases the gurney, which continues on a collision course with the expansive wet lab window. Images of the traveling gurney extracted from the stunt footage were reduced in size and skip-framed. Other elements in the composite included a matte-

whole series of these pool mattes and put them into the shots.”

painted habitat exterior, and a live-action image of the lab and its occupants inserted in the window and digitally distorted to mimic the refractive qualities of glass.

While some storm shots began with plate photography from the live-action shoot, a number of wider shots in the sequence were entirely digital. ‘But in those shots,” noted Mesa, ‘though we were using the 3D Aquatica, 3D waves and 3D ocean, we still had 2D imagery of the real actors coming out of the doorway- though they were quite small. We mapped those images onto 3D objects that we call “cards,” and actually front-projection-mapped them onto our 3D imagery.” Final composites- even those that were entirely digital- sometimes included as many as two hundred layered elements. The demanding work was accomplished by a team under the direction of compositing supervisor David Fogg, using Chalice and Digital Fusion.

Having hooked Whitlock’s gurney onto a cable hoist lowered by the hovering aircraft, the scientists retreat to the wet lab, unaware that the cable has become caught on itself. When the cable release suddenly gives way, Whitlock drops like a stone into the sea. Early shots out the helicopter door, straight down onto Whitlock being pulled up, featured CG ocean swells, while a later wide shot, from above the injured man dropping away, consisted of the real helicopter, real actor and a real splash element mapped onto a 3D ocean.

Dangling from the jammed cable, Whitlock quickly becomes shark bait when the Gen 2- a Conti robotic- grabs the cabled gurney in its jaws and pulls it under Aquatica. Shots of the helicopter veering wildly made use of the live-action set, with the real aircraft replaced by a full-size mockup suspended from a construction crane. Spinning rotor blades were produced digitally by Flash Film and tracked to the mockup.

Its pilot unable to disengage the cable, the helicopter veers out of control and slams into the control tower, killing those on board plus one of the Aquatica crew stationed in the lookout. Although the crash was originally filmed on set using the helicopter mockup and a series of full-scale explosions, Harlin and Okun were unhappy with the level of destruction and arranged for an additional element to be filmed at Grant McCune Design, using a miniature helicopter that was crashed into a black box roughly configured in the shape of the control tower. The Flash Film crew subsequently matched the miniature to the mockup, animating 3D blades on the helicopter as it broke apart and adding a series of exploding blade and debris elements.

The crash triggers a series of bigger explosions as Aquatica’s fuel tanks ignite, and the docked seaplane blows up. For several high-angle views of the control tower disintegrating, Flash Film Works composited 3D ocean and storm elements into the live plates, together with a CG plane breaking apart and scattering debris. Additional above-deck views of the fiery destruction included totally-3D shots in which pyrotechnic elements were composited onto the 3D Aquatica, with some aftermath fires added. Below the surface, McAlester and her team watch helplessly through the wet lab’s undersea window as the Gen 2 swims into view with Whitlock and the gurney in its jaws.

Several shots of Whitlock still strapped to the gurney in the mouth of the approaching mako were created by Hammerhead, using their CG shark in combination with a live-action plate in which a stunt double for Stellan Skarsgård was strapped onto a gurney and filmed underwater.

“The tracking was especially difficult,” said Theresa Ellis, “because it’s a complicated move. The shark is close, coming toward camera, and it’s 3D-rotating at the same time. We used our “Ras_track” program- a tracking program Thad wrote and for which he won a technical Academy Award. It allowed us to track points on the gurney, back out the camera information, then apply that to the shark and lock the two together again. We put some slippage back into the shot, adding a little error so it looked more realistic.”

In a deliberate maneuver, the mako swims full-speed at the lab window and slams the gurney into it. Cinesite replaced a greenscreen element on the live-action set with a CG window; then animated a series of cracks spider-webbing across the surface of the glass. “The crack continues to grow through a sequence of shots until the window breaks,” explained Cinesite visual effects supervisor Jerry Pooler. “We had to match a particular design the director had in mind for the cracking, then blend our CG window into an exploding glass effect that was done with a practical model.” Simulating the look of two-foot-thick glass presented a number of challenges for the digital artists, who animated the effect in Maya. “You would think that creating a crack in glass would be easy; but just getting the dimensions of the glass to look right, and the extrusions to look as if they’re occurring from the outside in was very difficult. Plus, the animation wasn’t random. Each crack had to pop on at a specific time over the course of the entire sequence.”



Aquatica team members run for high ground as the wet lab window implodes and the ocean rushes in. Plate photography for the sequence was accomplished on the full-size set, with a giant greenscreen rigged to represent the undersea aperture.

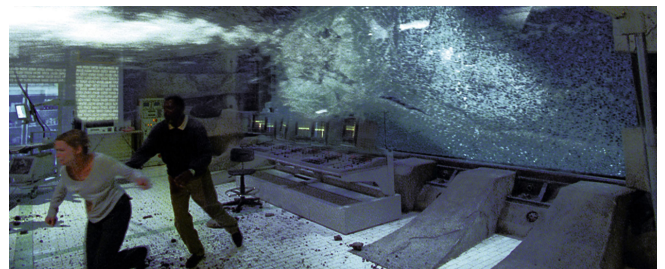
The window implodes and ocean rushes in, submerging the wet lab in seconds as the crew scrambles up a stairway and into an upper-level corridor of the breached habitat. Flooding of the wet lab, filmed in the indoor tank in Rosarito, was one of John Richardson's more hazardous assignments. Four large tip tanks were rigged to deliver 150 tons of water onto the set in a sudden rush. Simultaneously, the set- on its hydraulic riser- was lowered at a rate of four feet per second into the rushing water. 'We were controlling somewhere around a million pounds of weight going up and down on the riser,' said Richardson. 'With a thing like that, you can't afford mishaps; so we did quite a bit of work on the riser beforehand to make sure everything was within safe, workable parameters. I calculated what the load was on the cables and pneumatics, and we ended up putting around 200,000 pounds' worth of buoyancy into the underside of the set to lessen the weight on the cables.'

Having infiltrated the habitat, the sharks begin navigating its flooded corridors, relentlessly stalking the humans and getting them to flood key areas of the habitat that will bring the sharks to the surface and to freedom. In a series of encounters with the predators, two of the crew are dispatched, including engineer Tom Scoggins (Michael Rapaport), who is ambushed by the Gen 2 inside the submerged control room when he tries to activate an emergency generator needed to pump water from a flooded escape route.

Scoggins' death scene was one of the first to be addressed by the Hammerhead crew, and one that would result in a substantial redefining of Jeff Okun's digital shark strategy. Initially, the Hammerhead animators had tried to match as closely as possible the look and performance of the mechanical sharks; but having done so for an early shot in the Scoggins sequence, they encountered a lukewarm response from Harlin and the studio. 'It was a classic mistake on my part,' Okun conceded. 'We'd been doing exactly what was ordered and what was correct to do for continuity- we put the live-action character in our CG shark's mouth and matched the mechanical as closely as possible. And everybody said: "Yeah. It's amazingly like the animatronic." I thought that was a good thing, but what they were thinking was: "Why did we bother with CG?" So after a few days of decoding what it was people



At Grant McCune Design, modelmakers and stage personnel prepare a quarter-scale miniature of the set- complete with gurney and Whitlock figurine- for an exploding-glass effect in which the wet lab window is detonated and the gurney propelled toward camera in a rush of water.



The final composite- assembled by Cinesite- featured a seamless digital blend of live-action and miniature photography.

were really saying, I went back to Hammerhead and we redesigned the digital sharks. We made them dirtier and more scarred, we added nictitating eyelids- the white layer that lowers over the eyes during an attack to protect them- we extended the drop of the upper jaw, which is really the scary part of a shark, and we made the thing move a whole lot faster and with more weight. Then the Hammerhead crew took off in its own direction, and within a week knocked out a new version of the Scoggins sequence that made it look like this shark was the most evil thing in the world.” The new version, reworked by animator Andy Tamandl, cranked up the speed, power and violence of the CG shark enormously. ‘We showed it to Renny and the studio, and it knocked their socks off. They were all going: “Okay. Every CG shark has got to be that vicious. No more wussy sharks.”’

The redesigning of the sequence would have further repercussions. Upon viewing the first rough cut of the movie, both Harlin and the Warner executives had begun having second thoughts about how the live-action sharks were coming across on screen. ‘Walt’s work was incredible,” Okun stated. ‘When we first saw the animatronics in the tanks, everybody was duly impressed. And when we shot them and cut them together, everybody was duly impressed. But once the whole movie was cut together, the studio suddenly realized that there were no dynamics to the mechanical sharks, because they operated at full blast all the time. And the timing couldn’t be changed with optical tricks because of how that would change the water surrounding the sharks. It wasn’t that Walt’s sharks had failed in any way- they were so good, in fact, that the production had tended to push them to the max of what they could do every time. As a result, we lost the impact of a difference between a slow-moving shark and fast-moving one.”

At that juncture, Okun orchestrated an eleventh-hour push into the virtual realm in order to beef up the digital shark presence in the film. Though above-water shots of the sharks cresting in the water or otherwise interacting with the ocean surface would remain principally the province of Conti’s animatronics, CG sharks would supplement or, in some cases, entirely replace them in underwater stalking and attack scenes. For Hammerhead, the shift in emphasis to CG meant the late addition of some twenty effects shots- eleven of them unscripted. Since Hammerhead had all it could handle, Okun assigned another twenty-three shots to Industrial Light & Magic- twenty for a revamped end sequence, and the other three serving as transitions designed to make the sharks appear more vicious.

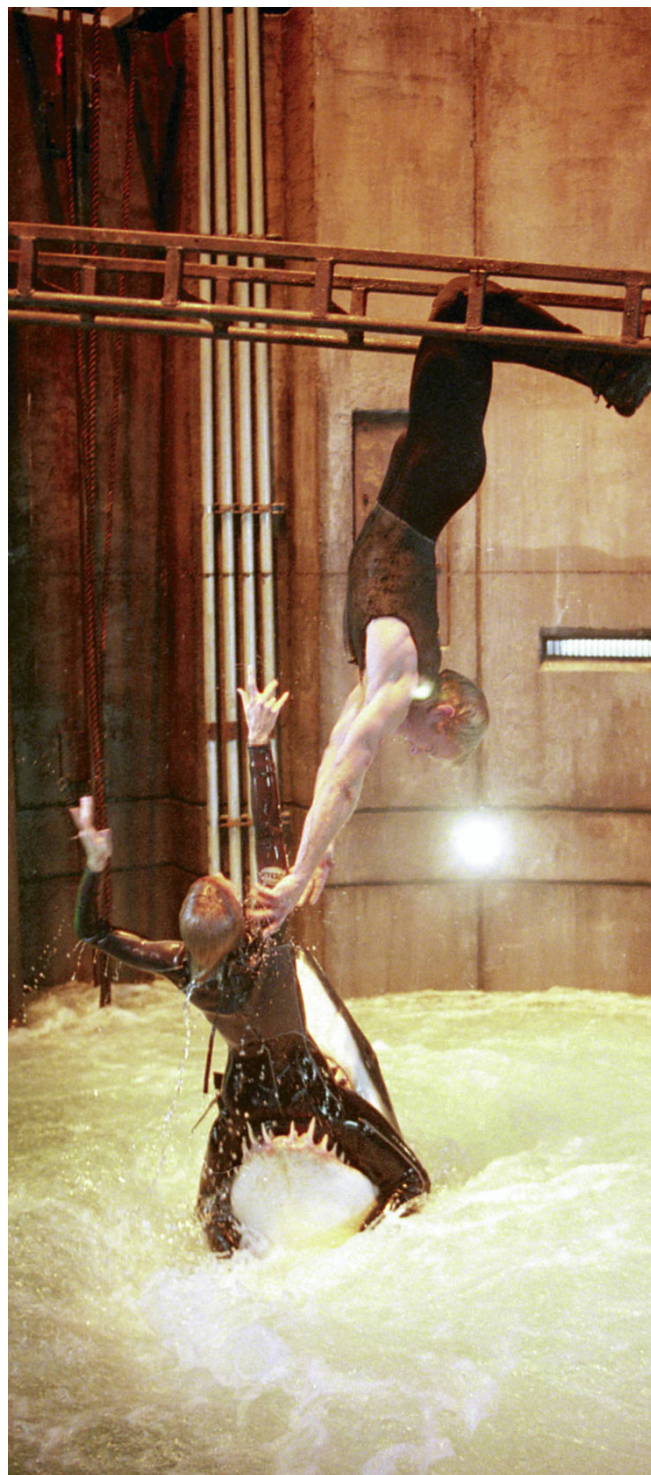
One such segue followed a scene in which Russell Franklin, standing at the edge of the wet lab pool, is snatched by a shark erupting from the water. In a shot Okun jokingly referred to as his “Ode to Jurassic Park,” a second shark approaches the first, and the two of them engage in a grisly game of tug-of-war. Another segue providing a gruesome close to the Scoggins death scene had the engineer’s still-kicking legs floating away from the smashed electrical panel as the Gen 2 swims off with his upper torso. ‘The mandate in those shots,” stated ILM visual effects supervisor John Knoll, ‘was to be horrific on a conceptual level, but not necessarily graphic in terms of blood and guts. They’re shocking moments; but the intent was to imply the horror, not to show every nasty little detail.”

For these and other shots under their jurisdiction, Knoll and CG supervisors Doug Smythe and Doug MacMillan set about adapting Hammerhead’s digital shark model to their own software

system. ‘Unfortunately,” Knoll remarked, ‘Hammerhead’s shark was a polygonal model, and our system is patch-based. So we had to go through the process of reskinning their shark for our system. Since we had a couple of shots where the camera is very close to the shark’s gaping mouth, we also added more painted detail inside the mouth and on the teeth. The other thing we added was flesh simulation. One thing we’ve seen in a lot of the reference footage on real sharks is that their gills flap, almost like fabric. Also, in many of our shots, the shark is doing violent maneuvers. When that happens, ripples travel down a shark’s body, almost like it’s made of Jello- and that was something we wanted to bring to the animation. Fortunately, we were doing this work on the heels of *The Mummy*, for which we had developed a lot of nice volumetric flesh simulation that we were able to put to use.”



As the desperate survivors search for an escape route, the sharks- which have entered the breached habitat- launch a deadly offensive. In Aquatica's flooded kitchen, Sherman "Preacher" Dudley (LL Cool J), eludes a Gen 1- a Walt Conti animatronic mounted on its motion base - by scaling a metal shelving unit.

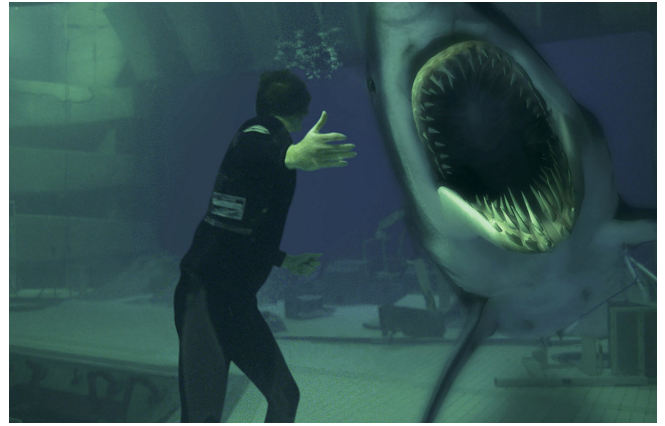


Marine biologist Janice Higgins (Jacqueline McKenzie) is less fortunate, falling off a ladder into water rising rapidly in an elevator shaft. Shots of Higgins in the mouth of a waiting Gen 1 were captured on a full-size shaft set, with Conti's mechanical shark mounted on a motion base rigged for vertical movement.

Despite the odds stacked against them, the humans are not the only ones suffering losses below deck. As the sharks move deeper into the habitat's sub-levels, the two smaller makos are dispatched by the more resourceful of Aquatica's crew. Chief cook and bottlewasher Sherman "Preacher" Dudley (LL Cool J) manages to get the upper hand after one of the sharks rams the oven he is hiding in and turns on the gas. Shots of the shark stalking Preacher in the flooded kitchen made use of Conti's animatronic on the live-action set, as well as Hammerhead's CG shark, featured in an above-water closeup of the creature's dorsal fin and in several shots of the shark lunging at the camera through the shelves of a CG storage unit in the foreground. "That was a big deal for us, because you get so close to it," explained Theresa Ellis. "We had to put a lot more texture on the shark's teeth, detail in the gums, and show all the scrapes and scratches and bruises on its skin. Then we added shadows on the floor, reflections in the water, fog and particulate, caustic light coming through the water and highlights on top of the shark. It was a major animating and compositing effort."

Escaping the oven, Preacher outsmarts the shark by beating a hasty retreat, but not before flicking his trusty Zippo lighter and throwing it into the gas-filled room. Film Factory and Men in White Coats worked jointly to supply the lighter effects for the sequence. "LL Cool J could not get the lighter to work on the set," commented Okun, "so we had to do a CG flame for it in all of the shots. Then they did a 3D lighter for a shot in which he throws the Zippo and it hits the nose of the shark and bounces off." Men in White Coats also did a series of explosion effects depicting the gas igniting, while scenes of the shark blowing apart featured a practical explosion element captured on the set by the physical effects team. Finally, the two digital vendors collaborated on a giant fireball that bursts through the door, nearly incinerating Preacher.

In another close call, McAlester, who has gone to her quarters to retrieve some vital scientific data, electrocutes the second Gen 1 by shoving a live electrical conduit into its gaping mouth as it tries to take her. Initial views of the shark emerging from the water were shot on location with a Conti animatronic. However, ILM- in another bid to heighten the effect- added a



The Gen 2 bears down on station engineer Tom Scoggins (Michael Rapaport) as he completes repairs on an electrical panel in the flooded control room. The sequence - one of the first addressed by the Hammerhead crew - would prove pivotal in determining the eventual look and performance of the digital sharks.



Digitally manufactured blood and bubbles cloud the water as the mako whips by camera with lightning speed.

terrifying closeup, viewed from over the shoulder of McAlester, of the Gen 1 leaping out of the water toward camera.

A particularly challenging sequence, in terms of both practical and digital effects, was one in which the survivors attempt to climb up a burning elevator shaft to the surface level before fires and rising flood waters seal off their escape. During the climb, marine biologist Janice Higgins (Jacqueline McKenzie) loses her footing and falls into the water, where she is snatched in the jaws of a Gen 1. Plate photography for the sequence was filmed in Mexico on a full-size, forty-foot segment of the 220-foot shaft, built into one of the studio tanks and then flooded.

Hammerhead created a CG shark for a handful of shots of the Gen 2 circling in the waters below; but for the attack on Higgins, staged on the live-action set, Walt Conti mounted his animatronic shark to its motion base, rigged to move vertically. Greenscreen elements of the actors were inserted into additional shots of the burning shaft, executed as a quarter-scale motion control miniature by Grant McCune Design. The entire sequence was assembled by Manex Visual Effects in Alameda, where technical designer George Borshukov and his team employed a virtual cinematography technique, previously developed for *The Matrix*, to extend the live-action sets digitally in approximately thirty of the shots.

One unusual element used to heighten suspense throughout the film was an effect Okun dubbed “shark vision”- which provided periodic glimpses of intended targets as seen from the shark’s point of view. Before it was popularized by *The Matrix*, Okun had planned on using a variation of that movie’s “bullet-time” effect- an effect in which an isolated image is frozen while the moving camera continues to pan- for the POVs. However, upon learning of the gimmick’s extensive use in *The Matrix*- scheduled for release well before *Deep Blue Sea*- Okun had reluctantly abandoned the idea, convinced that its novelty would be considerably diminished. Casting around for another fresh idea, Okun began working with Cinesite to develop a new look. ‘We came up with a distortion effect that is similar to using a fish-eye lens,” said Jerry Pooler. ‘We divided the image into a series of concentric rings; and while the center of the image remains fairly sharp, as it progresses through the other rings to the outside edges, it gets more and more distorted. Then, because there was some concern that it looked robotic, we gave it a more organic feel by animating it so that as you get further out to the outside rings, it looks like it’s in a liquid state.” Fourteen shots



Following a late decision to beef up the digital shark presence in the picture, Industrial Light & Magic was commissioned to execute several segue shots involving the shark attacks, plus a revamped ending for the film. ILM visual effects supervisor John Knoll oversaw the eleventh-hour endeavor.



ultimately featured the shark POV effect. ‘Lubo Hristoff came up with the basic design for it. Then we handed it off to lead compositor Marcel Martinez, who incorporated it into our 2D compositing packages.”

The Gen 2 shark, having made its way to the surface of the sinking habitat, attempts to break through perimeter fencing separating it from the open sea. ILM adapted the Hammerhead model to its own unique specifications, making use of breakthrough volumetric flesh simulation, and supplying additional painted detail to the mouth and teeth to accommodate closeup views.

Following the claustrophobic action in the bowels of Aqua-tica, Deep Blue Sea concludes topside, as McAlester, Carter and Preacher attempt a “do-or-die’ swim to the surface of the sinking habitat. While all three pop to the surface, Preacher suddenly finds himself grabbed and propelled violently through the water by the surviving Gen 2. ‘That was our homage to the opening bit with the girl in Jaws,” conceded Okun, who staged the scene in the big outdoor tank at Rosarito. Conti’s shark was used in concert with a hydraulic rig and cable-controlled dolly, which the physical effects crew built to drag the actor through the water. A CG fin was added in postproduction by VisionArt.

Preacher stabs the shark’s eye with his cross pendant, causing the monster to release him. A stuntman was positioned inside the mouth of the animatronic shark for some of the wider, more violent shots. ‘Walt’s shark truly worked great,” declared Okun. ‘It was one of his best sequences. The shark was thrashing in the water and whipping our stunt guy around. It was the last scene to use the mechanicals; so, since Walt didn’t need to worry about damaging it, he went nuts.”

Determined to destroy the shark before it can break through the steel perimeter fences topside and reach the open ocean, Carter and McAlester attach a makeshift bomb to a harpoon gun. When the creature swims out of shooting range, however, McAlester lures it back by leaping into the water and using herself as bait. Unable to save her, Carter, too, ends up in the water as the mako homes in for a final kill. Pulling a “matador’ maneuver for which he is famous, the shark wrangler evades the attack by hoisting himself up onto the beast’s dorsal fin. Meanwhile, the injured Preacher takes up the harpoon and fires, skewering both the shark and Carter’s leg in the process.

Upon viewing a rough cut of the finale- which had Carter managing to disengage himself moments before the shark is blown up- the filmmakers decided the ending needed more punch. So an additional scene was conceived in which Carter – pinioned to the fish and unable to disentangle himself- is dragged on a wild ride beneath the sea as the beast attempts to shake him off. ‘The shark is basically doing a slalom pattern,” explained Okun, ‘going through underwater concrete pilings, banging against them, trying to scrape him off. Then it apparently gives that up and blasts through the fencing as Carter tries to keep from being dragged through. At that point we cut to Preacher, who finally detonates the bomb. As the explosive shockwave rushes toward us, the camera pulls back through the hole in the fence to reveal Carter hanging onto it. Then the shockwave hits. The whole ending is much more dynamic.”

The added twenty shots were consigned to ILM, which was given a bluescreened element of Thomas Jane, captured during a quick two-day shoot at Motion Control Rental Services in Van Nuys. ‘We commissioned freelancer Bill Shourt and Grant McCune to build a rig that could

simulate the bucking motions of the shark,” remarked Okun. ‘Bill discovered that an effects man by the name of John Gray had already built a hydraulic motion control rig; so we got that rig out there and built a little bluescreen-covered shell for it- a half circle that was about eight feet by four feet, covered in tracking marks. We only had Thomas Jane for two days, because he was working on another movie, so we flew him in for the session, filmed him hanging on the rig, then flew him back. We got the Hammerhead guys to set up all the tracking and witness points, and take down all of the camera information we thought we’d need.”

For ILM animation director Dan Taylor, the biggest challenge was in getting a realistic CG shark performance that matched the bucking movements of the rig in the bluescreen plates. ‘As soon as we saw the bluescreen plates,” commented John Knoll, ‘we knew the shots would be difficult. Because the actor was riding the shark, we had to match the mockup’s movement, at least at the point of contact. When it came to actually animating a CG shark that moved like the mockup, it was hard to get natural swimming motions. That was a challenge we had to address on a shot-by-shot basis.”

A CG model of Thomas Jane also had to be built for a shot of Carter doing his matador move. With the actor unavailable for cyberscanning, ILM modelers depended on head shots, reference photography and measurements to build the model. The digital human would later be given a new paint job and revised proportions so that it could also function as a Samuel Jackson stunt double during his character’s earlier death scene.

In the absence of underwater plate photography, ILM created synthetic ocean environments for each shot in the sequence. ‘We were dealing with the undersurface of the water,” stated Knoll, ‘so we did a kind of blue fog environment, with shards of light steaming through and little particles in the water. We got Jeff to send us some outtakes of stuff shot with the Walt Conti shark, wet for wet, and we scanned in a bunch of those so we could base our look on that.” For a final view of the explosion shockwave rocketing toward camera, Okun provided the ILM team with a similar element left over from Sphere, which they retrofitted into the shot.

Through guerrilla filmmaking, the Deep Blue Sea visual effects campaign came in under budget and ahead of schedule - a feat that Jeff Okun attributed to the incredible effort put forth in every area of production, from the arduous and physically demanding shoot to the intensive postproduction push that resulted in new and creative solutions to some difficult issues. ‘The teamwork and the dedication on this show were unbelievable,” Okun declared. ‘Everyone did truly amazing work, going well beyond what was asked of them.”

That “above the call of duty’ mentality was evident at the top, as well, where Harlin and Okun challenged each other to push every envelope. ‘Renny and I- we’re an odd couple,” Okun reflected. ‘I’m always reminding him that effects are great, but effects don’t make a movie; and he’s constantly reminding me that I need to come up with bigger and better ideas. He throws the gauntlet down, and says: “Come on. If you knew what you were doing, you’d be able to create some spectacular effects, despite this paltry budget.’ Those were the kinds of challenges we presented to each other on Deep Blue Sea.”

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